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TECHNOLOGY REVIEW

March 1957

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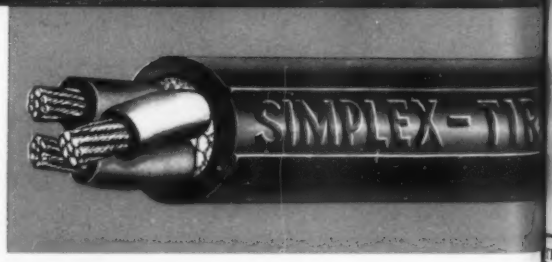

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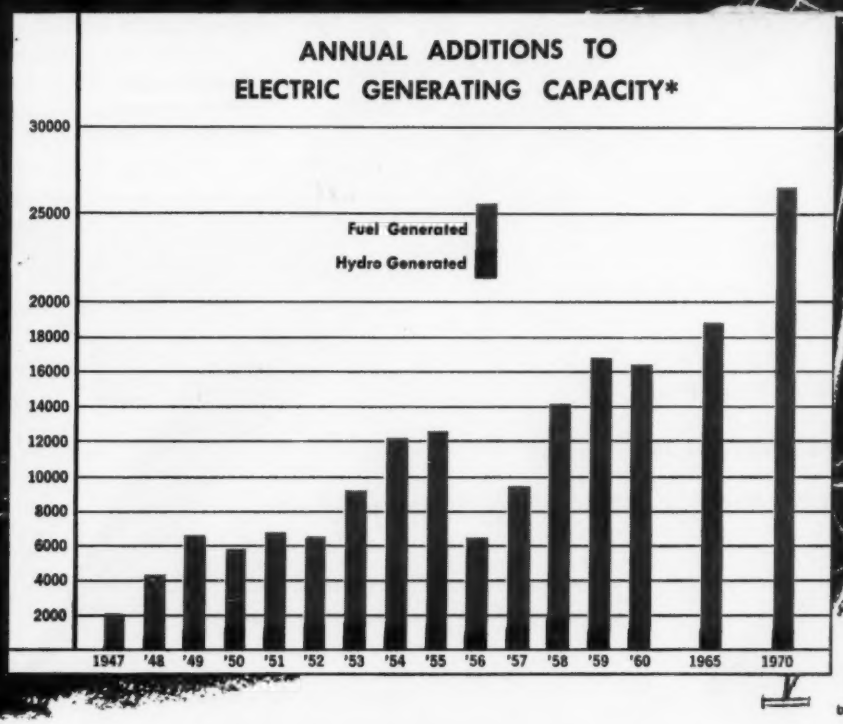
Why Combustion is accelerating its expansion program



The chart shows the rate at which America's utility industry has been expanding for the past decade and its projected rate of expansion to 1970. What this rate of growth means is dramatically illustrated by the fact that the total new capacity to be installed in the next decade will substantially exceed the total capacity the utility industry has attained in the 75 years it has been in existence.

Because electrical consumption reflects our national prosperity and living standards, this chart also indicates the progress we have been making as a nation and the progress we can anticipate for some years to come. It is doubly significant to us at Combustion since the largest part of our dollar volume comes from sales of utility boilers, and the second largest part from sales of boilers and other equipment to industry whose annual rate of growth roughly parallels the rate of power expansion.

To keep abreast of power expansion, Combustion increased its manufacturing capacity *more than 50 per cent* in the five-year period ending in 1955. And it is now engaged in the biggest expansion program in its history – not only to assure its ability to meet the ever-growing demand for conventional boilers, but also to prepare itself for a major role in the rapidly developing field of nuclear power.

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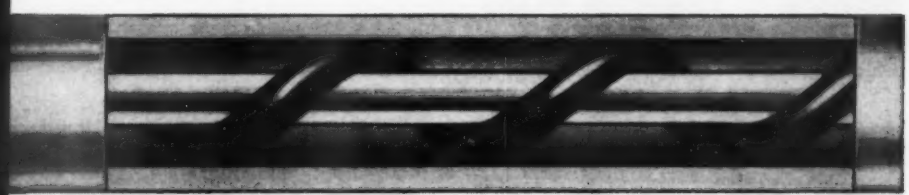

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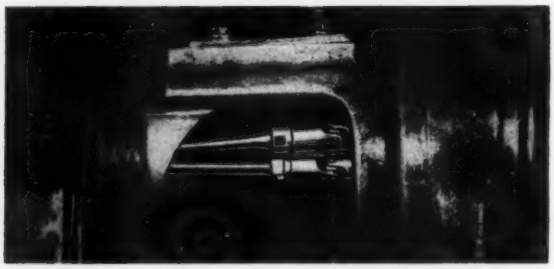
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint. **The solution** was a Curtis Universal Joint of the same size but higher torque.

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DIEFENDORF GEARS

THE TABULAR VIEW

Education for Understanding. — What a nation's educational system should be depends upon the nation's way of life, as LEE A. DUBRIDGE pointedly relates (page 245). Dr. DuBridge reveals his lifelong career as scientist and educator in stating his belief that the basis of true education is the acquisition of the language of words and numbers, an ability to comprehend, and a desire to continue learning. "Education for Understanding" was originally presented as an address at the Ninth Annual Conference of the Institute of Food Technologists, Southern California Section, in Pasadena, on November 9, 1956. A native of Terre Haute, Ind., Dr. DuBridge received the A.B. degree in 1922 from Cornell College (Iowa) and the Ph.D. degree in 1926 from the University of Wisconsin. He was a fellow of the National Research Council, 1926-1928 and then taught physics at Washington University where he was assistant professor in 1928-1933 and associate professor, 1933-1934. From 1934 to 1946 he was professor of physics and chairman of the Department at the University of Rochester, and was also Dean of the Faculty of Arts and Sciences there from 1938-1942. From 1940 to 1945 he was director of the Radiation Laboratory at M.I.T. Since 1946 Dr. DuBridge has been president of the California Institute of Technology.

Low-Temperature Switch. — A new circuit element has recently been added to useful devices from which large-scale computers can be designed. The new device, called the cryotron, is essentially a conductor operated at temperatures approaching that of absolute zero where superconductivity is achieved. The cryotron, described on page 249 of The Review, was developed by DUDLEY BUCK, '52. For his paper, "The Cryotron—A Superconductive Computer Component," in the April, 1956, issue of the *Proceedings of the Institute of Radio Engineers*, Mr. Buck will receive the Browder J. Thompson Memorial Prize of the I.R.E. Mr. Buck was born in San Francisco and received his early education in Santa Barbara. He received the B.S. degree in electrical engineering from the University of Washington in 1948, and then served two years as communications officer with the U.S. Navy.

(*Concluded on page 230*)

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9 CONTRACTS FOR CANADA DRY

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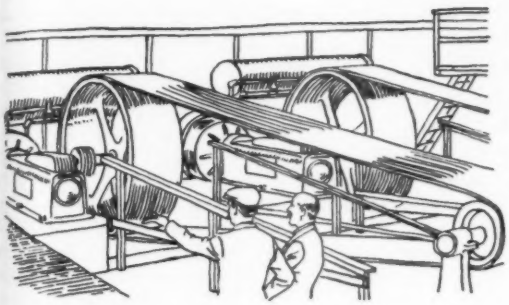
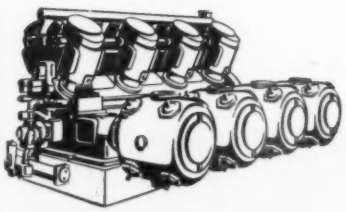


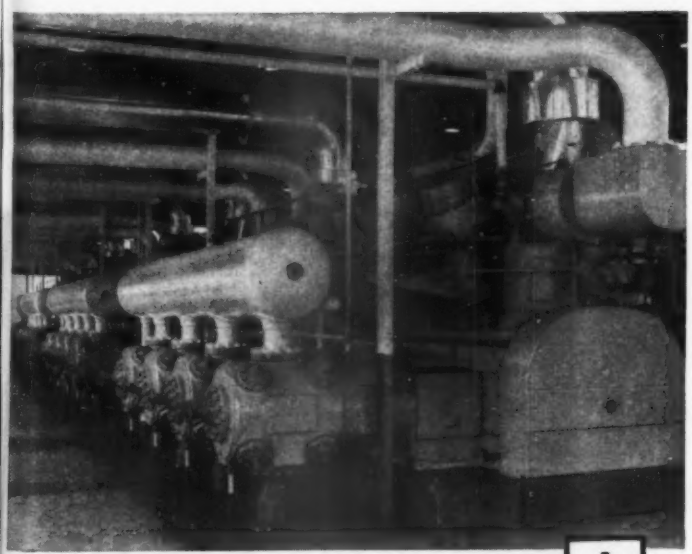
oil field compressors featured long belt drives like this...

IN THOSE DAYS, a compressor was one thing and a gas engine was another. When you hooked them together with a long belt you used up most of a large building. The "no-man's-land" between the units was useless — uninhabitable because of the dangerous flying belts.

25 YEARS AGO...



INGERSOLL-RAND led compressor manufacturers in the development of integral gas engine compressors, pioneering a new concept in compressor design, the revolutionary V-angle engine. This was the famous "XVG," which used articulated connecting rods — the first of the 4-cycle, V-angle engine-compressor family by Ingersoll-Rand.



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THE TABULAR VIEW

(Concluded from page 228)

He became a research assistant in the Institute's Servomechanism Laboratory in 1950 and in 1952 received the S.M. degree from M.I.T. He has taught electrical engineering at M.I.T. and Northeastern University, and is a staff member of the Research Laboratory of Electronics and of Lincoln Laboratory.

Our Talented Children. — As the trend toward free education at constantly higher academic levels surges on, and as the tax dollar is being called upon to support a growing percentage of educational institutions, there is growing need for maintaining high standards in our educational process. A new proposal, aimed at providing first-class education for our talented children at the secondary-school level, is proposed (page 250) by ADMIRAL H. G. RICKOVER. The Review's study is condensed from an address given at a luncheon sponsored by the Thomas Alva Edison Foundation, Inc. in East Orange, N.J., on November 20, 1956. Admiral Rickover is a graduate of the United States Naval Academy with the Class of 1922. Since then he has advanced from ensign to rear admiral, and in 1930 became qualified submariner. He was assigned to the atomic submarine project with the Atomic Energy Commission at Oak Ridge, 1946-1947, and since 1947 has been with the Bureau of Ships. Currently Admiral Rickover is chief of Naval Reactors Branch, Division of Reactor Development of the U.S. Atomic Energy Commission, and assistant chief of the Bureau of Ships for Nuclear Propulsion.

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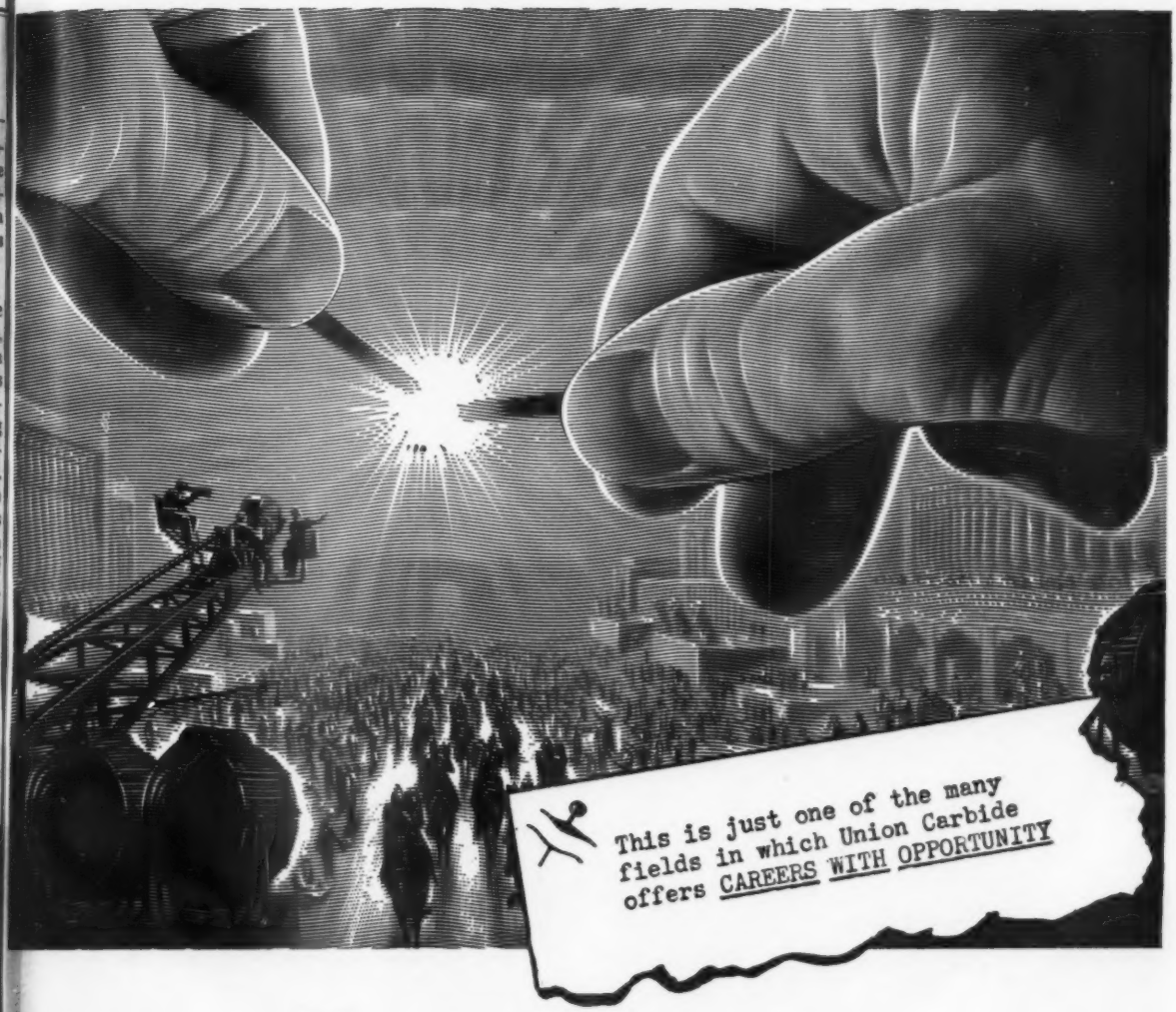

The sun that never sets

FOR YEARS, movie makers have relied on the powerful carbon arc to light their motion picture studio sets. It gives them brilliant, man-made "sunlight" for use when and where it is needed.

Recently, Union Carbide—a pioneer in carbon-arc lighting—perfected a new yellow flame carbon arc for use in color photography. It gives off a perfectly balanced light which brings out true colors on today's sensitive film. This development has been recognized by the award of an "Oscar," symbol of highest achievement in the motion picture industry.

But the carbon arc is not limited to studio lighting alone. Its intense beam is also used to project the tiny picture on the film to the breathtaking realism and depth you see on theatre screens.

Many more uses of this amazing light have been developed—duplicating the effect of sunlight on new paint and textile colors . . . or analyzing the basic composition of a great many different materials. The scientists of Union Carbide will continue their research efforts to find new and better ways to make carbon serve all of us.

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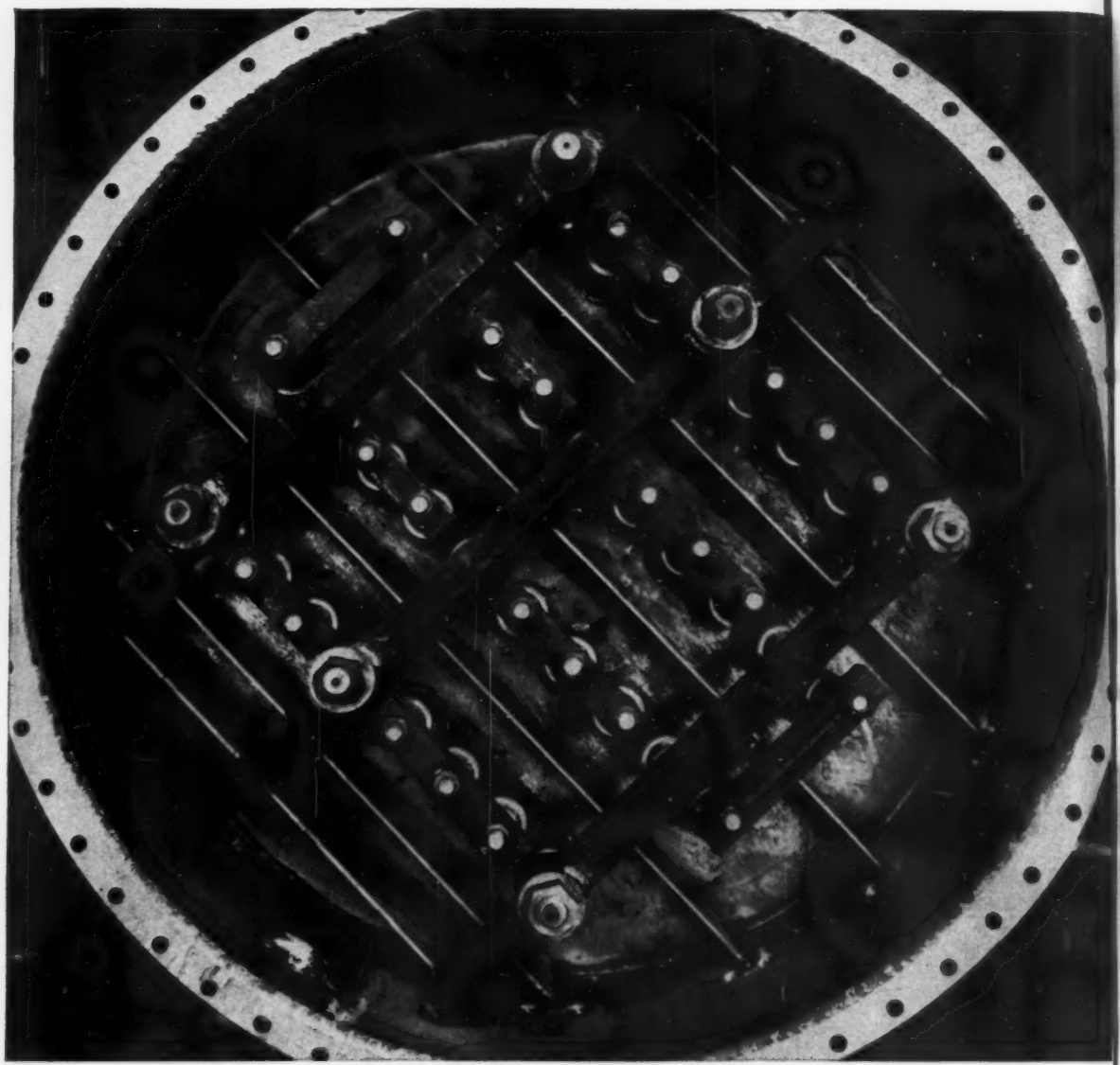

THERE'S MORE TO AN EGG THAN THE SHELL . . .

What's inside the shell really counts most. Take this section of a Type 347 stainless steel tower. The complex interior design required exacting craftsmanship—no more so, however, than is customarily applied to every Graver project. Graver's alloy fabricating skills and experience cover a wide range of work from the simplest vessels to mammoth field erected towers and tanks. Whether your project calls for stainless steel, stainless-clad, nickel-clad or other miracle metals, Graver craftsmanship assures rigid conformity to specifications.

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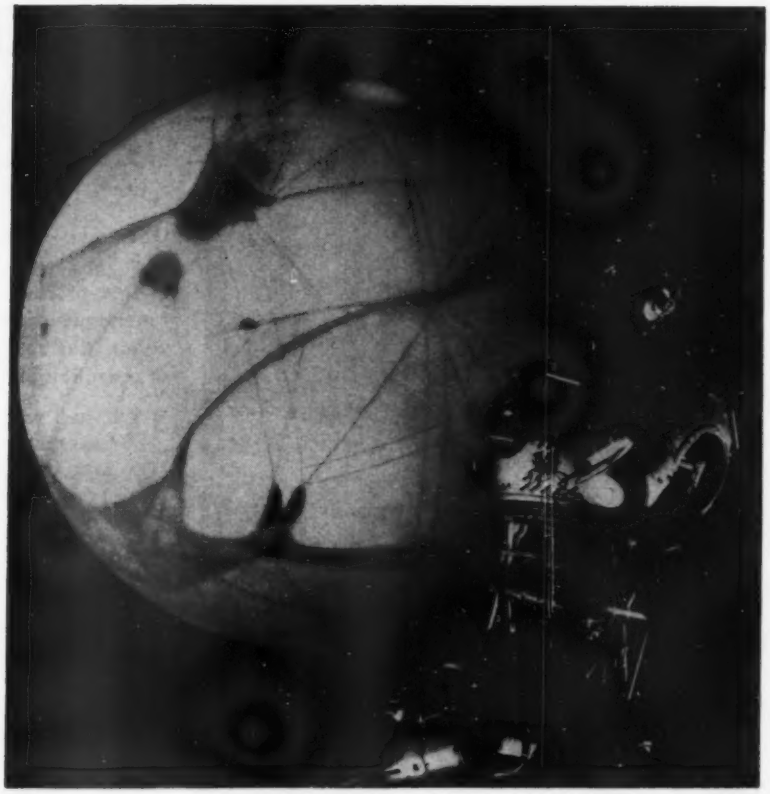

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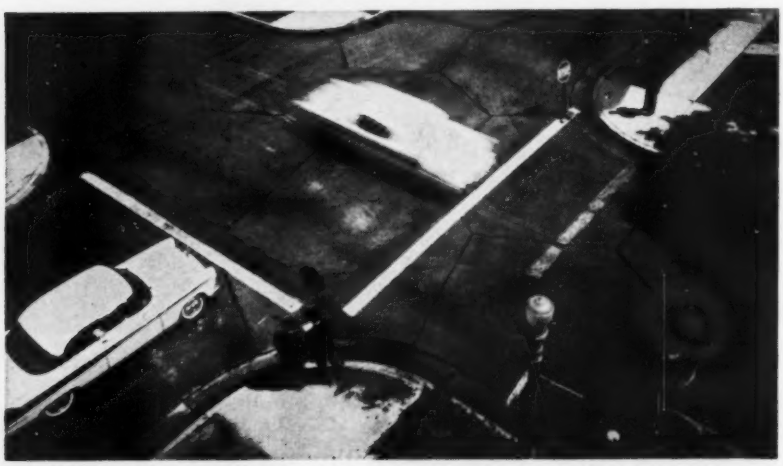

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Look for this nearby Goodyear dealer sign for better tire values . . . better tire care . . . convenient credit terms.

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Kenneth E. Bell, '17
Crusader Castle, near Homs, Syria

Technology Review

TITLE REGISTERED, U. S. PATENT OFFICE

Edited at the Massachusetts Institute of Technology

VOL. 59, NO. 5 MARCH, 1957

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The Technology Review

VOL. 59, No. 5 MARCH, 1957

The Trend of Affairs

The Alumni Ballot

■ In accordance with a March custom, and this year on the 25th of that variable month weatherwise, M.I.T. Alumni will receive ballots bearing the names of nominees to hold office in the Alumni Association, to become alumni term members on the Institute's Corporation, to serve as members of the National Nominating Committee from Districts 3, 6, and 7, and to participate as class representatives on the Alumni Council. There is no variability, however, in the continued loyalty and keen interest of the nominees.

Gilbert M. Roddy, '31, XV, has been nominated to serve as president of the Association for the year beginning July 1, 1957. Mr. Roddy is vice-president of the Boston Manufacturers Mutual Insurance Company and Mutual Boiler and Machinery Insurance Company which is located in Boston. His industrial achievements and Institute activities are recorded below his photograph.

Nominated to serve as a vice-president for a two-year term, effective July 1, 1957, is D. Reid Weedon, Jr., '41, IX–B, who is vice-president of Arthur D. Little, Inc., of Cambridge. He has gained familiarity with Association affairs through membership on the Alumni Council since 1952, and as a member of the Executive Committee in 1955–1957. He has been a member of the Committee on Nominations for Departmental Visiting Committees during 1954–1957, serving as chairman in 1956–1957. In 1951 Mr. Weedon was named Class Agent, as well as chairman of the Tenth Reunion for his class. For Alumni Day, Mr. Weedon was deputy chairman in 1956, and chairman in 1957. Since 1954 he has been director of the Phi Beta Epsilon Corporation, serving as chairman of the House Committee. Holding membership in the Algonquin Club, Chemists Club, Duxbury Yacht Club, and the American Marketing Association, he also serves on the Foreign Affairs Committee of the Cambridge Chamber of Commerce, and the Packaging Committee of the National Security Industrial Association.

◄ *Music room of the Charles Hayden Memorial Library provides students with pleasant opportunities for study or relaxation, as shown on the opposite page.*

For President 1957–1958 . . .

Nominated for the presidency of the Alumni Association for the fiscal year 1957–1958 is Gilbert M. Roddy, '31, XV. Mr. Roddy is vice-president of the Boston Manufacturers Mutual Insurance Company and Mutual Boiler and Machinery Insurance Company in Boston. Mr. Roddy was vice-president of the Association for 1954–1956, chairman of the Alumni Day Banquet in 1955, Class Representative on the Alumni Council since 1936, Class Agent, 1940–1942, and member of the Advisory Council on Walker Memorial in 1935–1938. He has served on many Alumni Association committees and had an active part in the Institute's $20,000,000 Development Fund Drive.

Active in community affairs, Mr. Roddy is president and director of the Emerson Hospital, Concord. He is a trustee of the Boston Museum of Science, Wheaton College, Home Savings Bank of Boston, Phi Gamma Delta, and director of the Concord Community Chest. He is a member of the Longwood Cricket Club, Concord Country Club, the Commercial Club of Boston, the Merchants Club, and the Newcomen Society.

Eastman Kodak Company *M.I.T. Photo*

Newly appointed alumni term members to serve on the M.I.T. Corporation are (left to right): *Charles A. Chayne, '19, Vice-president in charge of Engineering Staff, General Motors Corporation; Clarence L. A. Wynd, '27, Vice-president, Eastman Kodak Company and Assistant General Manager of the Kodak Park Works; and Theodore T. Miller, '22, President of the Polymer Chemicals Division, W. R. Grace and Company, and President of the Alumni Association for 1956–1957.*

The two Alumni nominated by the National Nominating Committee as members of the Executive Committee for two-year terms, beginning next July, are: Raymond A. St.Laurent, '21, X, and William L. Taggart, Jr., '27, XV. Mr. St.Laurent is vice-president of Rogers Corporation, Rogers, Conn., and Mr. Taggart is executive vice-president of Dewey and Almy Chemical Company (Division of W. R. Grace and Company), Cambridge.

Nominees as alumni term members on the M.I.T. Corporation, to serve for five years, are: Charles A. Chayne, '19, II, Vice-president in charge of the Engineering Staff of General Motors Corporation; Theodore T. Miller, '22, XV (who is serving as Association President for 1956–1957), President, Polymer Chemicals Division, W. R. Grace and Company, New Jersey; and Clarence L. A. Wynd, '27, X–A, who is vice-president of the Eastman Kodak Company and assistant general manager of the Kodak Park Works in Rochester.

The present membership of the National Nominating Committee includes: Horatio L. Bond, '23, chairman, Robert C. Erb, '17, Clayton D. Grover, '22, William S. Brackett, '23, Cecil H. Green, '23, Max L. Ilfeld, '24, David J. Sullivan, '24, Morgan Collins, '27, Ralph B. Johnson, '27, and Harold Chestnut, '39.

Nominees as members of the National Nominating Committee (with one Alumnus to be elected from each District) to serve for three years are: *District 3* – Springfield, Mass. – Bissell Alderman, '35, IV; Pittsfield, Mass. – Frank S. Gardner, '38, III, VIII, IX; *District 6* – Philadelphia, Pa. – Herbert W. Anderson, '15, II – Richmond, Va. – Richard H. Catlett, '17, X–A; Washington, D.C. – Robert K. Thulman, '22, XV; Bethlehem, Pa. – Michael V. Herasimchuk, '39, XIX; Pittsburgh, Pa. – Henry Avery, '41, X; *District 7* – Columbus, Ohio – Edmund D. Ayres, '22, VI–A; Toledo, Ohio – Herbert A. Barnby, '23, V; Chicago, Ill. – Philip L. Coleman, '23, XV; Louisville, Ky. – Albert L. Entwistle, '26, XV; Cleveland, Ohio – William C. Sessions, '26, XV.

Redfield Proctor: 1879–1957

■ Redfield Proctor, '02, ex-governor of Vermont, chairman of the board of Vermont Marble Company, and member of the M.I.T. Corporation, died in Proctor, Vt., on February 5, at the age of 77.

In addition to his distinguished public service and industrial leadership, Redfield Proctor was a wise supporter of our educational institutions. He was an active alumnus, a diligent life member of the Corporation, and a warm and ardent supporter of the Institute. Students, Faculty, and administrative officers knew him with love and affection, and feel a deep sense of loss at his passing.

Prominent in New England business, political, and educational service, Dr. Proctor was one of the founders and second president of the New England Council, served in the Vermont General Assembly and State Senate before his election as governor in 1923, was president of the Vermont Marble Company from 1935 to 1952, and was a lifetime trustee of Middlebury College, and the 40th president of the M.I.T. Alumni Association in 1933–1934. He held honorary degrees from Middlebury College, Norwich University, and the University of Vermont, and was trustee and director of many civic, educational, charitable, and business organizations.

Popular Science Lectures

■ Of the two Popular Science Lectures to be presented in 1957, under the auspices of the Society of Arts, that entitled "Why Metals Corrode" will be delivered on March 24 by Herbert H. Uhlig, '32, Professor of Metallurgy. The series opened on February 10 with the lecture entitled "Count Rumford, the Father of Applied Physics" by Sanborn C. Brown, 10–44, Associate Professor of Physics.

The Popular Science Lectures are delivered on Sunday afternoons at M.I.T. Tickets may be obtained, free of charge, upon application to the Society of Arts, Room 4–434 at the Institute.

To Head Biology Department

■ Irwin W. Sizer has been appointed head of the Department of Biology at the Institute, it was announced in January by George R. Harrison, Dean of the School of Science at M.I.T. Professor Sizer, who has taught physiology and biochemistry at M.I.T. since 1935, had been serving as executive officer and acting head of the Department. His portrait appears on page 240.

Dr. Sizer is well known for his studies of the fundamental properties and medical applications of enzymes, complicated organic substances that speed up chemical transformations. Slowing down, or inhibiting, enzyme action is one way of controlling disease. Dr. Sizer is currently studying the use of enzyme inhibitors as antibiotics and in chemotherapy.

"The effects of anti-cancer agents, insecticides, and drugs," says Dr. Sizer, "can often be explained in terms of enzyme inhibition. Moreover, the design and synthesis of new enzyme inhibitors offers great promise for the control and cure of disease in the immediate future."

Professor Sizer is also doing research on the medical aspects of enzymes as related to the treatment of burns. Experimental work with enzymes shows they may be especially useful in getting severe burn areas ready for skin grafts.

"Work on burns is receiving marked attention," says Professor Sizer, "because burn problems are expected to be severe if we should ever undergo atomic attack."

Dr. Sizer also has studied extensively enzymes which are concerned with the clotting of blood, and others which bring about the oxidation and destruction of the toxic irritants of poison ivy. In addition, he has worked on the spectroscopy and biochemistry of collagen and has done research in connection with the use of sheep gut, of which collagen is the principal constituent, for surgical sutures.

M.I.T.'s Department of Biology, which Dr. Sizer now heads, is unique among academic Departments for its concentration on modern analytical biology. The Department is doing pioneering research in many areas of biophysics and biochemistry. It is also a world center in biological research using the electron microscope, an instrument which makes possible the photography and study of structures approaching the molecule in size.

A native of Bridgewater, Mass., Dr. Sizer received his A.B. from Brown University in 1931 and his Ph.D. from Rutgers University in 1935. He came to M.I.T. in 1935 as instructor and research associate in biology and public health, became an associate professor in 1942, and executive officer of the Department in 1954. He was named acting head of the Department in 1955 and was appointed full professor in 1956.

He has been in charge of the graduate program for biology students at M.I.T. for many years and has been active on national committees for the improvement of educational opportunities and standards in the field of biology. In 1951, he was a visiting lecturer at Brown University.

Dr. Sizer is a fellow of the American Academy of Arts and Sciences and a member of the American Society of Biological Chemists, the American Physiological Society, and American Society of Zoologists.

On the Horizon

March 7, 1957 – M.I.T. Club of New York – Dinner at Longchamps Restaurant, 42d and Lexington Avenue, 7:00 P.M. **Speaker:** Eger V. Murphree, '23, Special Assistant to Secretary of Defense. Mr. Murphree will speak on "Guided Missiles." (For further information, consult Anton E. Hittl, '36, M.I.T. Club of New York, 33 East 48th Street, New York 17, N.Y.)

March 14–16, 1957 – 9th Annual Fiesta, M.I.T. Club of Mexico, Mexico City, D.F. (For reservations, consult Clarence M. Cornish, '24, Margaritas 139, Villa Obregon, Mexico 20, D.F., Mexico.)

June 10, 1957 – 23d Alumni Day, 1957, M.I.T. Campus in Cambridge.

September 6–7, 1957 – 2d Alumni Officers' Conference, M.I.T. Campus in Cambridge.

December 7, 1957 – 11th M.I.T. Alumni Regional Conference, Pittsburgh, Pa.

Communications Sciences

■ Claude E. Shannon, '40, one of the world's leading scientists in the field of information theory, has been appointed to the Faculty of the Institute, according to James R. Killian, Jr., '26, President. Dr. Shannon will have the unique dual title of professor of communications sciences in the Department of Electrical Engineering and professor of mathematics. For the past year Dr. Shannon has been visiting professor of electrical communications, while remaining a research mathematician on the staff of Bell Telephone Laboratories. He will continue collaborative work with Bell.

Dr. Shannon has achieved special eminence in the field of information theory, a new branch of science which combines the methods of mathematics and electrical communications in computing, automation, and areas of the behavioral sciences that bear on the relation of man to his environment. It encompasses such practical applications as the nationwide automatic telephone system and devices by which streams of electrons can be translated into television pictures. A particularly fertile field in the application of information theory deals with effective means of squeezing more information into a given communication channel. Late in January, Dr. Shannon was presented with the 1956 Research Corporation Award for his work on information theory.

As a member of the Institute Faculty, Dr. Shannon is expected to play a key role in the evolution of the new and rapidly expanding field of communications sciences, seeking to merge new segments of the vast areas of the physical and life sciences. Studies centered in the Research Laboratory of Electronics will attempt to integrate the disciplines of mathematics, electrical engineering, psychology, and physiology for the purpose of a better understanding of

M.I.T. Photo

Bell Telephone Laboratories

M.I.T. Photo

Among those recently appointed to new academic or administrative posts at the Institute are (in usual order): ***Irwin W. Sizer, who becomes head of the Department of Biology; Claude E. Shannon, '40, recently appointed professor of communications sciences in the Department of Electrical Engineering and professor of mathematics; and J. Edward Vivian, '39, Professor of Chemical Engineering, who became faculty assistant to Edward L. Cochrane, '20, Vice-president for Industrial and Governmental Relations.***

communications within man, communications and control between man and machine, and communications and control between machine and machine.

A native of Gaylord, Mich., Dr. Shannon received a B.S. in electrical engineering and mathematics at the University of Michigan and then came to M.I.T. for a master's degree in electrical engineering and a Ph.D. in mathematics. While a student here he wrote a thesis of such originality and significance that it had an immediate impact on the designing of telephone systems.

Dr. Shannon became a research assistant at M.I.T. in 1936 and an assistant in mathematics in 1938. For a time he was in charge of the M.I.T. differential analyzer. In 1940 he went to the Institute for Advanced Study at Princeton for a year and in 1941 joined the staff of Bell Telephone Laboratories.

Scientific papers by Dr. Shannon have ranged from those dealing with the theory of optimum transmission of information to theoretical studies of machines which would play chess and other games. He holds several patents.

Dr. Shannon's work has been recognized by the award of the Alfred Noble Prize of the American Institute of Electrical Engineers, the Morris Liebmann Award of the Institute of Radio Engineers, and the Stuart Ballantine Medal of the Franklin Institute. In 1954 he was awarded the honorary degree of master of science at Yale University. He is a member of the National Academy of Sciences.

Faculty Assistant to Admiral Cochrane

■ Announcement has been made of the appointment of J. Edward Vivian, '39, Professor of Chemical Engineering, as the Faculty Assistant to Admiral Edward L. Cochrane, '20, Vice-president for Industrial and Governmental Relations, as of January 1. Professor Vivian will retain his association with the Department of Chemical Engineering and continue his teaching.

Born in Montreal, Canada, in 1913, Professor Vivian studied at McGill University and received the degree of B.Eng. in 1936. As an assistant he joined the staff of the Institute's Department of Chemical Engineering in 1937, and in 1939 and 1945, respectively, obtained his S.M. and Sc.D. degrees from M.I.T.

He became assistant professor of chemical engineering in 1942, associate professor in 1946, and attained a full professorship in 1956.

Professor Vivian has held several administrative posts, beginning in 1938 when he became assistant director of the Bangor Station of the Chemical Engineering Practice School, and then director of the Buffalo Station in 1941. Continuing with administrative duties, in 1943 he was acting director of the School of Chemical Engineering Practice, and became director in 1946. He was appointed director of the Oak Ridge Engineering Practice School in 1948.

The directorship of the School of Chemical Engineering Practice and the Oak Ridge Engineering Practice School will be assumed by Robert C. Reid, '54, Assistant Professor of Chemical Engineering.

Arthur D. Little Visiting Professor

■ Lars G. Sillen, distinguished Swedish scientist and Dean of the Chemistry Department at the Royal Institute of Technology in Stockholm, has been named Arthur D. Little Visiting Professor of Chemistry at the Institute for the current semester.

His lectures on "Studies on Chemical Equilibria," are to be delivered during the next three months. Members of the M.I.T. Chemistry Department and all chemists in the Boston area are invited to attend these lectures (the first of which was presented on February 18) to be given on Mondays and Wednesdays at one o'clock.

M.I.T. Photos

William H. Radford, '32 (left), and Carl F. J. Overhage (center) have been appointed associate director and director, respectively, of Lincoln Laboratory, research unit operated by M.I.T. They succeed George E. Valley, Jr., '35, who returns to M.I.T. as professor of physics, and Marshall G. Holloway who takes an important industrial assignment in nuclear science. At the right is Lynwood S. Bryant, Associate Professor of English and History, recently appointed Director of The Technology Press.

Direct Lincoln Laboratory

■ Appointment of Carl F. J. Overhage as director and of William H. Radford, '32, as associate director of Lincoln Laboratory was announced on February 4 by President Killian. They succeed, respectively, Marshall G. Holloway and George E. Valley, Jr., '35, who have resigned.

Dr. Holloway came to the directorship of Lincoln Laboratory in May, 1955, from the Los Alamos Scientific Laboratory in New Mexico, and will go to a new position in industry. Dr. Valley, promoted from associate to full professor of physics, is returning to Faculty service on the M.I.T. campus in Cambridge. He became associate director of Lincoln Laboratory in 1953. During World War II he was on the staff of the M.I.T. Radiation Laboratory and served as technical editor of the laboratory's Office of Publications. He has received the President's Certificate of Merit and the Department of Defense Exceptional Service Award for his contributions to defense work.

Dr. Overhage, a native of London, received B.S., M.S., and Ph.D. degrees in physics in 1931, 1934, and 1937, respectively, from the California Institute of Technology. He was a group leader at the Radiation Laboratory during World War II, was on the staff of Eastman Kodak Company for five years, and in 1951 returned to M.I.T. as member of a group studying special problems of national defense. He joined the newly organized Lincoln Laboratory, then returned to Eastman for a time and served the Air Force as a member of the Scientific Advisory Board to the Chief of Staff before becoming a division head at Lincoln. He has specialized in the development of data transmission and in prototype evaluation for the SAGE system of air defense. His special scientific interests are in radar and photography.

Dr. Overhage was awarded the President's Certificate of Merit for his technical contributions in World War II. He is a fellow of the American Physical Society and a member of the Optical Society of America, Sigma Xi, and Tau Beta Pi. He lives in Belmont. Dr. Overhage has been head of Division II, Aircraft Control and Warning, at Lincoln.

Professor Radford, who was born in Philadelphia, received a B.S. degree at Drexel Institute of Technology in 1931, and an M.S. degree from M.I.T. in 1932. He has been on the staff of the M.I.T. Department of Electrical Engineering since 1932, becoming a full professor in 1951. In 1941 he assisted in establishing the M.I.T. Radar School and he became associate director of it in 1944. He was a section member and consultant to the National Defense Research Committee from 1940 to 1943.

In 1953 Professor Radford went to Lincoln, where he has pioneered in the development of scatter radio communications, the "over-the-horizon" system which is used for all communications between the mainland and the Texas Tower and for other purposes. He has been head of Division III, Communications and Components, which also carries on research and development in such scientific fields as solid state physics.

Professor Radford is a fellow of the Institute of Radio Engineers and of the American Association for the Advancement of Science and is a member of the American Society for Engineering Education, the American Institute of Electrical Engineers, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He lives in Watertown.

Technology Press Director

■ Lynwood S. Bryant, Associate Professor of English and History, has been appointed director of The Technology Press, effective on February 1. Frederick G. Fassett, Jr., the former director, who became dean of residence last fall, will continue to serve on The Technology Press Board.

Victors clasp hands on the podium after the medal presentation for the Finn class yachting event at the St. Kilde Yacht Club in Melbourne, Australia, as Olympic yachting comes to a close on December 6. First place went to P. B. Elvestrom of Denmark (center) and second place went to A. Nelis of Belgium (left). John Marvin, '49 (right), representing the United States, won third place and a bronze medal.

On the basis of usual scoring in which all races in the series have equal value and all races count, Marvin had by far the best score, and led for the first two days of the Finn monotype dinghy class races late in November.

Wide World Photo

Professor Bryant is a native of Keene, N.H., was graduated from Harvard University and came to the M.I.T. staff in 1937. In 1942 he was made assistant professor, and was promoted to the grade of associate professor in 1946. Professor Bryant will continue to teach in the Department of Humanities.

The Technology Press was founded in 1932, and since 1938 has been under the general direction of The Technology Press Board, of which John E. Burchard, '23, Dean of the School of Humanities and Social Studies, is now chairman. The function of The Press is to assist members of the M.I.T. staff with the preparation and publication of books of intellectual importance or educational value. It welcomes titles that will yield an income, but it is also interested in important manuscripts without the sales potential attractive to commercial publishers. The Press is also prepared to handle preliminary versions of text material to be tried out in the classroom for a year or two before being finally revised into a book.

In recent years The Press has broadened its interests and grown rapidly. It now has a list of some 60 titles. Most of its books are published under a special contract which makes available to The Press all of the production and distribution facilities of an established commercial publishing house.

Tech Sailors in Olympics

■ A bronze medal, emblematic of third place in the Finn monotype dinghy class, rewarded the effort of John Marvin, '49, in the 1956 Olympics held in Melbourne, Australia, during the last week in November. The only other medal won by a United States yachtsman was a first place gold medal won by Herbert Williams of Chicago in his Star class yacht *Kathleen*.

Marvin compiled a fine record finishing second to Paul Elvestrom of Denmark, the 1948 and 1952 Olympic champion, in the first race of the seven. He placed second to Andre Nelis of Belgium in the second encounter and by finishing eighth (to Elvestrom's sixteenth place) in the third race, jumped into the lead event as Nelis was disqualified. Marvin led for two days but then first places by Elvestrom gave him the series. Marvin was tied for second place, as Nelis went into the last race, but finished astern of Nelis to land in third place.

Scoring under the Olympic system is by a weighted formula giving a large bonus to the top positions. Seven races are sailed and one may be discarded. Ironically, scoring by the usual system of equal value for places and counting all races in the series, Marvin had by far the best score. Andre Nelis was forced to retire from one of his races and Paul Elvestrom's sixteenth place was discarded and so did not penalize their score.

C. Eric Olsen, Jr., '39, sailing in the two-man Sharpie class finished a disappointing ninth of 18 competitors, the winner being the yacht *Jest* of New Zealand. Olsen's boat arrived in Australia with its mast and rigging lost in transit and the hull badly dried out. Getting the boat ready for the series left little time for practice. The high spot in his experience was a race where the wind increased to 50 miles an hour in which he placed fifth and was the last boat to finish the course. As a final tribulation, his boat was swamped in breaking seas near shore after finishing.

Both M.I.T. graduates extolled the hospitality of the Australians and described enthusiastically the experience of living in the Olympic village among the athletes of the world. Their enthusiasm is shared by Walter C. Wood, '17, Sailing Master at the Institute, who from the Sailing Pavilion loft continues to scan the waters of the Charles for embryo Olympic contestants among the neophyte members of the M.I.T. Nautical Association.

Twenty-five Years Ago This Month . . .

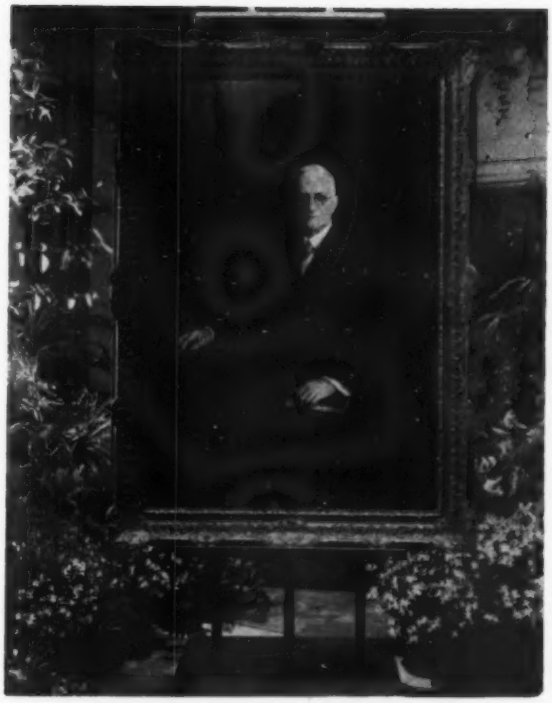
■ On March 14, 1932, the Institute mourned the passing of George Eastman, the "Mysterious Mr. Smith" whose anonymous support had enabled President Richard C. Maclaurin in the years immediately preceding World War I to proceed confidently with M.I.T.'s removal to the present location in Cambridge, which was dedicated in June, 1916. In the words of Carl W. Ackerman, his biographer, writing in The Review:

"George Eastman's interest in this institution covered a span of more than 40 years and during the greater part of this period he was an inconspicuous and detached student and beneficiary.

"During these years of industrial expansion in the United States, graduates of Technology came in increasing numbers to Rochester and to other industrial centers. As Mr. Eastman observed them and studied the annual reports of Technology, he became convinced that 'the progress of the world depends almost entirely upon education.' Then when he reached the distributive period of his own life, he was prepared to coöperate with and to encourage President Richard C. Maclaurin in building the Institute of Technology as it is today.

"Mr. Eastman himself never sought nor desired recognition. Early in his own career he had become convinced that 'individuals may form communities,' as Disraeli observed, 'but institutions alone can create a nation.' If Mr. Eastman could have distributed the bulk of his fortune as secretly as he did his income, it is doubtful whether his identity as 'Mr. Smith' would be known today. . . .

"At the time Mr. Eastman's biography was being written he did not know how much money he had actually given Technology. When a tabulation was finally obtained, indicating an amount of approximately twenty million, he studied the figures for several moments, and then remarked: 'In a few years that will not be very large, for Technology will grow.'"



George Eastman: 1854–1932

. . . Congratulations were being extended to Joseph E. Nute, '85, for being the recipient of the first Silver Beaver Award ever authorized by National Headquarters of the Boy Scouts of America; to Harry P. Charlesworth, '05, Vice-president of the Bell Telephone Laboratories, upon his nomination for the presidency of the American Institute of Electrical Engineers; and to James M. Barker, '07, upon his appointment as Vice-president in charge of Retail Administration of Sears, Roebuck and Company.

Individuals Noteworthy

■ Prominent in the news since the advent of 1957 have been the 21 Alumni promotions, elections, or appointments enumerated below:

Charles Edison, '13, as Chairman of McGraw-Edison, formed by the merger of Thomas A. Edison, Inc., and McGraw Electric Company . . . *Alfred W. Devine, '14,* as Deputy Registrar of Motor Vehicles of the Commonwealth of Massachusetts . . .

Charles J. McCarthy, '16, as a member of the National Advisory Committee for Aeronautics (succeeding *Arthur E. Raymond, '21*) . . . *Marvin Pierce, '18,* as Chairman of McCall Corporation . . .

David P. Brown, '20, and *Arthur R. Gatewood, '21,* respectively, as President and Vice-president for Operations of the American Bureau of Shipping . . . *Dana D. Sawyer, '22,* as Vice-president of the Federal Reserve Bank of Boston . . .

Dale D. Spoor, '22, as Vice-president of Air Reduction Sales Company . . . *Foster N. Perry, '24,* as Chairman of Robert Bosch Corporation . . . *Charles H. Wardwell, '24,* as a Director of the Rockland-Atlas National Bank of Boston . . .

Theodore A. Mangelsdorf, '26, as Vice-president of the Texas Company . . . *Elisha Gray, '28,* as a member of the Business Advisory Council of the United States Department of Commerce . . .

Eric A. Bianchi, '29, and *Paul Wing, Jr., '34,* respectively, as Vice-president and Chief Engineer of the Mason-Neilan Regulator Company Division of Worthington Corporation . . .

Gregory Smith, '30, as President and General Manager of Eastman Gelatine Corporation . . . *John B. Calkin, '32,* as President of Calkin and Bayley, Inc., industrial consultants . . .

Thomas F. Morrow, '35, as Vice-president of Chrysler Corporation . . . *H. Arthur Zimmerman, '37,* as Vice-president in charge of sales, Steel Improvement and Forge Company, Cleveland . . . *Donald P. Severance, '38,* as the 61st President of the Appalachian Mountain Club . . .

Wilbur F. Young, '45, as General Manager of W. F. Young, Inc., manufacturers of Absorbine Jr. . . . *Richard H. Harris, '48,* as Assistant Controller of Norton Company, Worcester, Mass.

■ Special honors recently announced or awarded to Alumni and members of the Faculty include:

To *Ralph T. Walker, '11,* and *Louis H. Skidmore, '23,* respectively, its Centennial Medal and 1957 Gold Medal by the American Institute of Architects . . .

To *Chester A. Boggs, '25,* a certificate as a Fellow, by the Audio Engineering Society . . . to *Charles Kittel, '38,* the Oliver Buckley solid-state physics prize for his applications of magnetic resonance methods to investigations of the electronic solids, by the American Physical Society . . .

To *Claude E. Shannon, '40,* its 1956 Award, by the Research Corporation . . . to *Jordan J. Baruch, '47,* named "the outstanding young electrical engineer for 1956," by Eta Kappa Nu, national electrical engineering honor society . . .

To *Dudley A. Buck, '52,* the 1957 Browder J. Thompson Memorial Prize for his paper, "The Cryotron — A Superconductive Computer Component," by the Institute of Radio Engineers . . .

To *Douglas W. Fuerstenau, '53,* and *Antoine M. Gaudin,* Richards Professor of Mineral Engineering at M.I.T., respectively, its Robert Lansing Hardy Gold Medal and Robert H. Richards Award, by the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Laboratory of Earth Sciences

■ To seek answers to such questions as — (1) Is it possible to modify the weather on a large scale? (2) What is the interior of the earth really like? and (3) Why do continents and oceans exist and why are they distributed as they are? — the Institute has established a Laboratory of Earth Sciences. The announcement was made in February by George R. Harrison, Dean of the School of Science.

Under the chairmanship of Professor Robert R. Shrock, Head of the Department of Geology and Geophysics, a special Faculty committee has been making a comprehensive formulation of M.I.T.'s goals in all aspects of science dealing with problems of the earth. It is upon this committee's recommendation that the Laboratory of Earth Sciences has been established to provide creative experimentation and research on the geophysical problems of the earth.

The laboratory, which will be under the direction of Professor Henry G. Houghton, '27, Head of the Department of Meteorology, will attempt a new and integrated approach to experimental and theoretical investigations of man's environment: the atmosphere, the oceans, and the land masses between, including the interior of the solid earth. The new laboratory will probably need to spice its science with a dash of imagination.

"Controlled imagination," said Dr. Harrison, "is often the chief tool of the earth scientist as he assails such questions as the formation of continents, the causes of climate, or the nature of the earth four billion years ago."

Jointly sponsored by M.I.T.'s Departments of Geology and Geophysics and of Meteorology, the new laboratory will become a research center for geologists, geophysicists, geochemists, meteorologists, and oceanographers.

M.I.T.'s Department of Geology and Geophysics is widely known for such diverse researches as the determination of the age of rocks by radioactivity, the development of new methods of exploration for mineral deposits, and the study of the structure of minerals by x-ray diffraction. Geology has been taught at M.I.T. since the founding of the Institute, and M.I.T.'s founder — William Barton Rogers — was a geologist.

M.I.T. also established the first formal program in meteorology in the country. It pioneered in developing many weather techniques and instruments now considered standard, including most recently the development of weather radar. Current research there is concentrated on the theoretical and physical approach to fundamental problems of the atmosphere.

Dr. Houghton, who will head the new laboratory, has been in charge of meteorology at M.I.T. since 1945 and a member of the staff there since 1928. He is well known for his research in cloud physics and atmospheric radiation and for some of his earlier studies with specific applications to aeronautics.

Midwinter Meeting

■ Highlight of the annual Midwinter Dinner Meeting of the M.I.T. Alumni Association, held at Walker Memorial on January 30, was a review of recent progress at the Institute by Julius A. Stratton, '23, Chancellor, and a panel discussion on "Technology and International Relations" by members of the M.I.T. staff. Panelists included: General James McCormack, Jr., '37, special adviser to President Killian, and also President of the Institute for Defense Analyses; Alexander G. Korol, a senior staff member of M.I.T.'s Center for International Studies; and Everett E. Hagen, Visiting Professor of Economics.

Max F. Millikan, Director of the Center for International Studies, led the panel discussion which followed a report on recent developments at M.I.T. by Chancellor Stratton. Meeting chairman was Theodore T. Miller, '22, President of the Alumni Association and President of the Polymer Chemicals Division of W. R. Grace and Company.

General McCormack, who was formerly director of research and development for the Air Force, spoke on the relationship between technology and national defense.

Mr. Korol, who has been studying Russian scientific education intensively for several years, compared and contrasted the techniques and results of United States and Soviet educational programs in science and engineering. It was Mr. Korol's view that Russian technical education at the Ph.D. level did not differ significantly from that in the United States, but that discrepancies showed up rather quickly at lower levels. This is attributed to the fact that Russian technical education is rigid with studies carefully prescribed. Graduates of secondary schools have much better preparation in physics and mathematics than many of the high school graduates in the United States. The technical institutes in Russia annually graduate about 140,000 technicians, or sub-profes-

(*Concluded on page 256*)

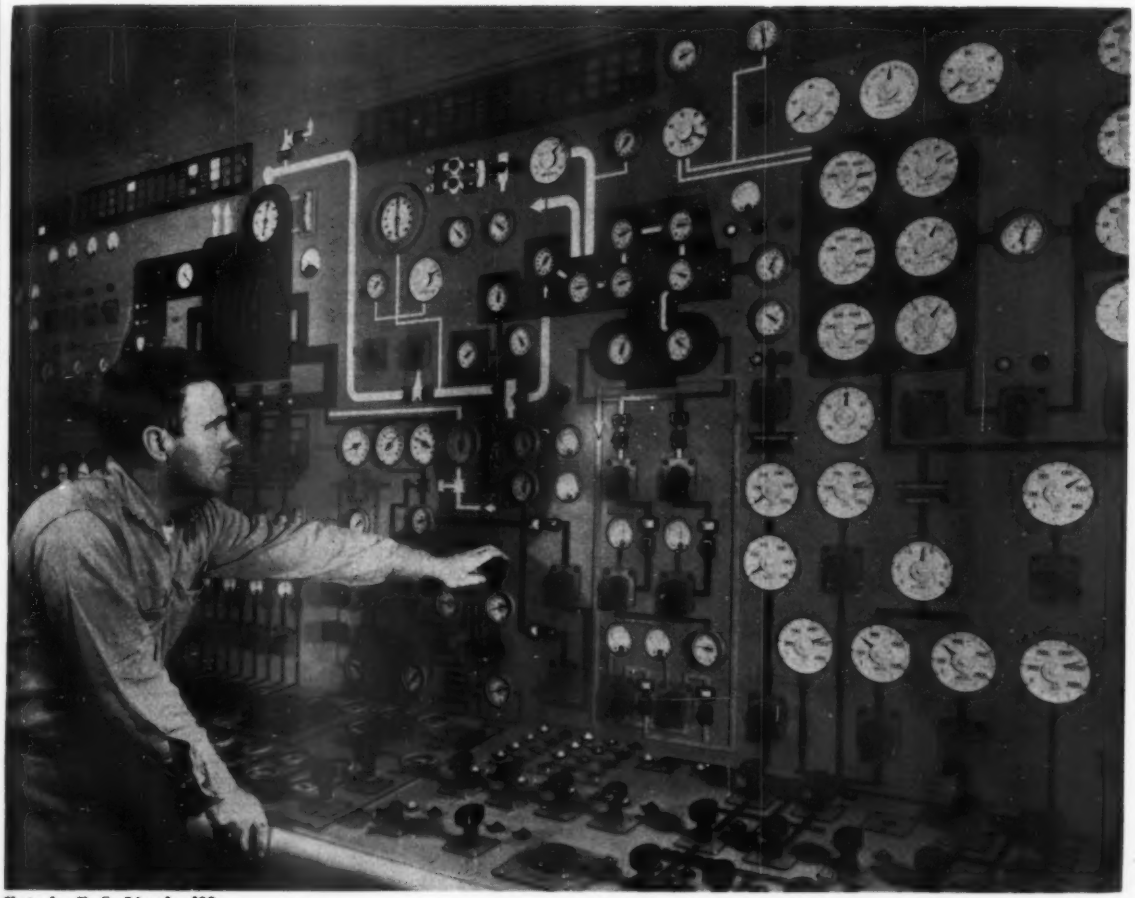


Photo by F. S. Lincoln, '23

Control panel of the Glenwood Landing Power Plant reflects the need of our modern industrial society for vast amounts of energy, for ample and adequate measuring techniques, and for effective techniques of control.

Education for Understanding

Acquisition of the language of words and numbers, of an ability to comprehend, and of desire to keep on learning is held to be the basis of education

by LEE A. DUBRIDGE

It may seem strange that our educational system in America today appears to be in such a crisis — in such a turmoil. From kindergarten to graduate school we find turmoil, unrest, uncertainty, dissatisfaction — a desire for change, coupled with uncertainty as to what kind of change. People have been educating their children for a long time. You would think we should have learned all about it by now. Why are we confused?

One reason is that it is only in the past century that the notion has become widespread that society should provide a free education for everyone. And, even today, that proposition is fully accepted only in a limited part of the world. And even then, in many countries, the concept does not extend beyond the sixth or eighth grades.

In fact, only in America — and even here only in the past 50 years — have we come to accept the double-barreled proposition, first, that free compulsory education should be provided for everyone through the 12th grade and, second, free education (but not compulsory) should be available to the Ph.D. degree for those who want it and can qualify.

We are, in fact, dealing with a new thing — a new experiment in social organization and custom. And new experiments, of course, always run into trouble. If we had been operating such a system for 1,000 years, we would have had time by now to have tried out dozens of ways of doing it; we could have observed the effects on many generations of students and would have learned about a lot of mistakes we would not need to make again; and we would have

evolved better methods of doing things. But we are just beginning to learn about universal education. It was only a few generations ago that education above the eighth grade was reserved for the wealthy — or for prospective lawyers, doctors, or preachers. "Storekeepers and farmers don't need no education; they got work to do." That's what they said!

Yes, public universal education is still an experiment and we are the generation who have the privilege of being pioneers in the experiment. We should not be surprised at our mistakes; we should not be surprised even if we cannot agree which things *are* mistakes. But we will be betraying future generations if we do not do our best to do a better job than previous generations have done. So the first difficulty with public education is its youth.

The second difficulty with education is that the world in which the educated people have to live keeps changing. Some of us older folks went to public schools in the days before World War I. And here we are trying to live in the world of 1956. It is ridiculous really, isn't it? How could our dear teachers have possibly known in 1916 what we would need to know in 1956? Just think how hopeless it is to expect our public schools today to educate people to live in the world of 1996 when we haven't the foggiest notion of what that world is to be like?

Back in the Seventeenth Century it would not have been so bad. Things did not change much from generation to generation then. You could have adopted an educational system and tried it out for a few generations under practically the same conditions. You could conduct a controlled experiment! Now, however, when we try to educate the next generation as we think we ought to have educated the last one, we are almost certain to be wrong! The second trouble with education, then, is that the world is changing so fast that we cannot tell what we are educating *for*.

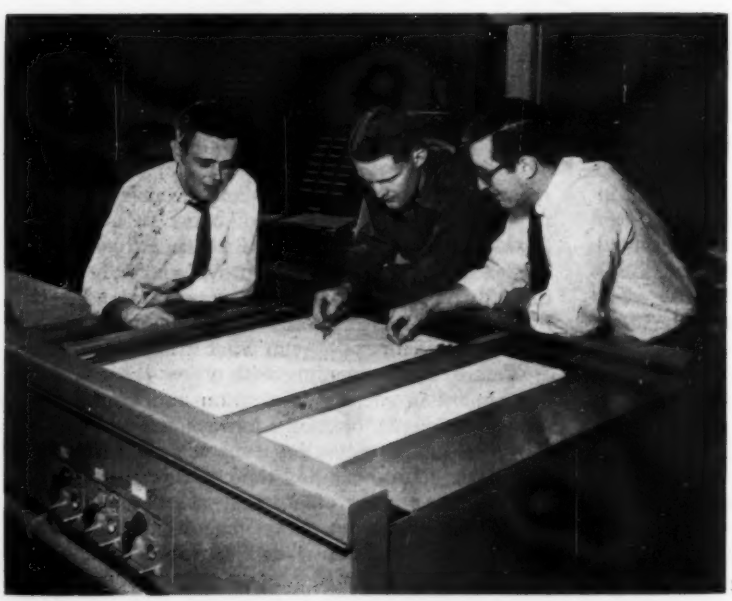
A striking example of this confusion in educational aims is found in an incident which took place in Colonial Virginia. I quote from an account written in 1899:

> After the principal business was settled, the commissioners from Virginia acquainted the Indians by a speech that there was at Williamsburg a college, with a fund for educating Indian youth; and that, if the Six Nations would send down half a dozen of their young lads to that college, the government would take care that they should be well provided for, and instructed in all the learning of the white people. . . . "We are convinced," the Indians replied, "that you mean to do us good by your proposal, and we thank you heartily. But you, who are wise, must know that different nations have different conceptions of things; and you will therefore not take it amiss, if our ideas of this kind of education happen not to be the same as yours. We have had some experience of it; several of our young people were formerly brought up at the colleges of the northern provinces and they were instructed in all your sciences; but when they came back to us they were bad runners, ignorant of every means of living in the woods, unable to bear cold or hunger, knew neither how to build a cabin, take a deer, nor kill an enemy, spoke our language imperfectly, were therefore neither fit for hunters, warriors, nor counsellors; they were totally good for nothing. We are, however, not the less obliged by your kind offer, though we decline accepting it; and, to show our grateful sense of it, if the gentlemen of Virginia will send us a dozen of their sons, we will take great care of their education, instruct them in all we know, and make *men* of them."*

Amusing? Yes. And yet, the gap between the Indians and the whites in 1750 was possibly no greater than that between our Twentieth and Nineteenth Century Americans.

It appears to be a piece of bad luck that we decided to adopt universal education at just the mo-

* Ford, Paul L., *The Many Sided Franklin*, pages 117–118 (New York, The Century Company, 1899). [Quoted by Gaylord P. Harnwell, President of the University of Pennsylvania, in his article "Reflections on Communicable Education and Its Enduring Values" in the *Association of American Colleges Bulletin*, October, 1956, page 363.]



M.I.T. Photo

The plotting of trajectories for guided missiles represents a good example of the need for emphasizing mathematics in modern education. As Dr. DuBridge remarks: "Not a machine can be designed, an engine's performance predicted, an electric power plant constructed, without mathematics through calculus. And the design of an airplane, a ship, a guided missile, or an electronic computer requires a profound knowledge of higher mathematics. And, of course, the really interesting fields of nuclear physics and astronomy use group theory, matrix algebra, and non-Euclidean geometry.

"In other words, no one from a grocer's clerk to the nuclear physicist can do without mathematics; and the study of mathematics can be a great adventure in the methods of quantitative thinking which will provide a lifetime of better understanding of a technological world."

ment in history when the world began to change so fast. But *is* it just a coincidence? Or is the world changing so fast just *because* we have public education?

We shall have to admit that the two are connected. The advances in science and technology which have made the world of 1956 so different from the world of 1856 have not been made by accident! They have come from the efforts and achievements of a host of *educated men.* And now we are trapped – for to keep this world going, we must have still more educated men to run it; still more to improve it further.

Education begets change. Then change demands not only more education, but a different education for every generation. Now we can see why professors have been writing so many books and articles on the subject of "education in a changing world." It may seem like a terribly trite subject – but it is still our most important problem. There is no use pretending we can educate for a static world. The world is going to keep on changing. And, curiously enough, the more we educate, even though we educate badly, the more change there is going to be.

Now let's see whether this leads to any conclusions about what our educational system ought to try to do, and what it should not do. There are a few general principles which emerge at once:

1. We should educate for the future – not for the past or even for the present!

2. We should emphasize those things which are permanent, or unchanging, or which change slowly, rather than things which will surely change or are changing rapidly.

3. Since principles or theories change more slowly than practices or procedures, we should emphasize basic fundamental *ideas* rather than more ephemeral, so-called practical matters. For example, the principle of the electric motor is a more permanent thing than the *design* of any particular motor. Also, the principles of the republican form of government are more lasting than the names of the present members of Congress.

4. However, in seeking the permanent or the lasting, we must not be confused and teach only the old, else we find ourselves teaching astrology rather than astronomy, alchemy rather than chemistry. False or useless things are often as old as the ages, while things eternally true may be as young as tomorrow.

5. Facts are quickly forgotten or become obsolete. But the ability to understand and use facts is a permanent asset. Hence it is more important to acquire understanding than to memorize facts.

6. Since we cannot hope to teach all the things the student will need to know 20 years hence, it is evident that what he learns is less important than acquiring the *desire* to learn. Conversely, if the love of learning has been killed by insistence on memorizing too many facts, then the child will surely some day be unprepared for life. For the facts he has learned will be forgotten or be partly obsolete, and the facility for learning new things will not have developed; understanding will not have been acquired. However, if the desire to learn and understand has been acquired, then our student will be ready for a changing world.

General Motors Research Staff

An advancing civilization requires an ever-larger fraction of its population to be engaged directly in scientific and technological pursuits.

I could go on enumerating more of such principles and giving more examples. But I think we can summarize the aims of education in a changing world as follows: (1) Acquire the tools of learning – reading, speaking, writing, arithmetic – that is, the language of words and the language of numbers; (2) Acquire the ability to understand – to comprehend – to think; (3) Acquire the desire to keep on learning – to keep on understanding.

If the student has achieved these things, he is ready for higher education or ready to acquire the vocational skills required to embark upon a useful career.

So much then for the general philosophy of education. A general philosophy does not, of course, solve the million practical problems which our schools face, such as teachers' salaries, teacher shortage, classrooms, curricula, costs, taxes, athletics, and so on. But without a general guiding principle, our educational system can end in chaos.

In some respects it is now in chaos. There are so many thousands of things that a modern American citizen ought to know that our curricula are jammed with bits of this and bits of that. We have not yet realized that it is impossible to teach a person in school all the things he ought to know all his life. Learning those things will be his life's work. The function of the school is to provide the student with the tools and the motivation necessary for him to go on learning all his life.

Now, if you will forgive me, I want to speak as a scientist. I fear that our schools are neglecting an important part of this task of providing the student

with the intellectual tools he will need to live a useful and fruitful life in modern America. Let me explain.

It takes only a little thought to realize that the one thing that has made the big difference between the Western world of today and the world of the time of Christopher Columbus is the growth of science and technology. When men like Columbus and Magellan began to break through geographical frontiers and then men like Leonardo da Vinci and Galileo and Newton began to break down intellectual frontiers, mankind was led to a new era of understanding and hence a new era of achievement. When it was discovered that nature behaved in precisely regular ways – in accordance with "laws" which men could discover and understand – then men became the masters of their environment and were no longer the slaves of imaginary demons. Then men began to use their understanding to improve their physical well-being. They developed machines to help them in their work; learned to use fire not only as a source of heat, but as a source of work, of energy, or power. Then came the abolition of slaves, because their work could be done better by steam. Modern industry was created; transportation and communication were revolutionized. And the world we know took shape.

Tools of Education

Now I think it is appropriate to suggest that the graduate of an American high school should be equipped to understand the nature of this world in which he is to live. I do not say he must know all about it; that is impossible for anybody. I do say he should have been introduced to the tools and the methods which will enable him to understand; and also he should have acquired a feeling that attaining understanding is desirable and useful. What are these *tools* he needs?

First of all, it must be emphasized that modern science and engineering are exact sciences – they are quantitative sciences. That means that their results can be stated in numbers; that their language is the language of mathematics. The engineer does not design a bridge, an automobile, an airplane or an atomic bomb by guessing about it! He must calculate the precise design of every detail – of every nut, bolt and screw; of every rod and plate. He must balance every factor – each part must be large enough to do the job, but not too large, too heavy or too expensive. Any automotive engineer could, no doubt, design a car that would last 100 years. But it would probably weigh 10 tons and cost $1,000,000. He must balance endurance against cost – not by guessing, but by calculating and by testing.

And so it is with everything we touch. We live in a world of technology, and technology is a world of numbers and equations. Is it right to allow our high school graduate to emerge so ill-equipped that he has not the slightest chance of entering the world? I do not mean entering it professionally – though an ever-increasing fraction must do that too. I mean entering it intellectually – having a little appreciation for what it means and how it came to be. For example, it would be of immediate practical help for the student to know what it means to say that the kinetic energy of the car he is driving varies as the square of the speed. How many do?

A letter to the editor of a Los Angeles paper recently expressed the fear that California might be hurt by the blast of a Bikini test bomb several thousand miles away. Apparently the argument is that if a 20-kiloton bomb produces damage out to three miles, then a 20-megaton bomb (1,000 times as big) will produce damage to 3,000 miles. But the damage radius varies as the cube root (the one-third power) of the energy. To produce an increase in damage area by a factor of 1,000 would require an increase in energy by a factor of 1,000 cubed – that is by a *billion*.

I noted recently a curious example of this inability to deal with numbers larger than a billion. A science story in a weekly news magazine contained the statement that in a certain volume of air there were "billions of molecules." Now of course that is perfectly true, but it is about as significant a statement as to say that on the earth there live "dozens of people." There are, of course, many dozens of people on the earth; in fact, there are about a quarter of a billion dozen. Similarly, there are many billions of molecules in a cubic centimeter of air; in fact, there are 30 *billion* billion molecules. We feel sorry for primitive men who were unable to distinguish numbers higher than three and who referred to everything else as "many." Some day in the future, people will think of us Twentieth Century humans as being rather primitive because we were unable to think in terms larger than a billion.

Our whole modern civilization is built on mathematics! Not a street can be laid, a foundation dug, or a building constructed, without the use of algebra, geometry, and trigonometry. Not a machine can be designed, an engine's performance predicted, an electric power plant constructed, without mathematics through calculus. And the design of an airplane, a ship, a guided missile, or an electronic computer requires a profound knowledge of higher mathematics. And, of course, the really interesting fields of nuclear physics and astronomy use group theory, matrix algebra, and non-Euclidean geometry.

In other words, no one from a grocer's clerk to the nuclear physicist can do without mathematics; and the study of mathematics can be a great adventure in the methods of quantitative thinking which will provide a lifetime of better understanding of a technological world.

Need for Mathematics

Also, mathematics is a subject which can best be studied at an early age – before 17. And when intelligently taught it is not beyond the capacity of the average student! In any case, the decision as to whether it shall be taught should rest not on its difficulty, but on its importance. The difficulty can be reduced by clever teachers if there is an incentive to do so. It will not be done as long as it is required that a mathematics teacher have more hours of education courses than of mathematics.

(*Continued on page 258*)

The Cryotron

Institute of Radio Engineers awards its 1957 Browder J. Thompson Memorial Prize for simple control mechanism developed

by DUDLEY BUCK

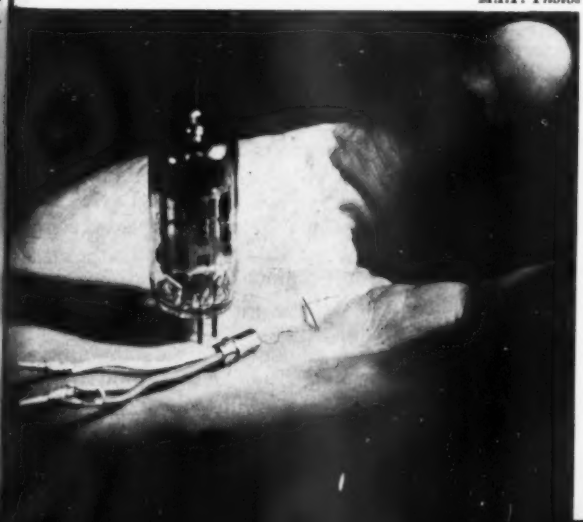
A NEW electronic circuit component, small in size, inexpensive to make, and easily fabricated from commercially available materials is a new development stemming from recent research at M.I.T. The new device, called a cryotron, makes possible amplification of current and power, is able to carry out switching operations, and gives promise of extensive application in large-scale computers. Because of its ability to amplify, the cryotron may be expected to compete with electron tubes and transistors in certain applications where very high speed of operation is not too important, but where small size is. The size of a cryotron, compared with the size of a transistor and a miniature type of vacuum tube, is shown in the illustration at the bottom of this page; the device is sufficiently small that 100 will fit into a thimble.

The cryotron is the result of researches in two entirely different fields, both of which have been pursued at the Institute for a number of years. The cryotron principle was developed by Dudley A. Buck, '52, as a result of studies, conducted at Lincoln Laboratory, on nonlinearities in nature with an eye toward computer applications. But the cryotron would have remained merely a scientific device of little use outside of the research laboratory without the availability of commercially practical refrigerators capable of maintaining temperatures at, or very close to, absolute zero. A rugged refrigerator, operating at the temperature of liquid helium (4.2 degrees K) and known as the cryostat, has been developed by Samuel C. Collins, Professor of Mechanical Engineering, and for the past few years has been produced on a commercial basis by Arthur D. Little, Inc.

Just removed from a container of liquid helium (4.2 degrees K) is this rod containing 40 cryotrons and held by Dudley A. Buck, '52. Mr. Buck began development of the cryotron three years ago at M.I.T.'s Lincoln Laboratory. He is an instructor in the Department of Electrical Engineering, and staff member of Lincoln Laboratory and also of the Research Laboratory of Electronics at M.I.T.

A miniature electron tube (left) and typical transistor (center) compared to a cryotron unit (right). The cryotron consists of a tantalum wire around which a niobium coil is wound. For computer applications the cryotron replaces electron tubes or transistors.

M.I.T. Photos



The cryotron is the first useful application of a phenomenon discovered in 1911 by H. Kamerlingh Onnes of Leiden. It makes use of that property of a metal, called superconductivity, by which its electrical resistance suddenly vanishes at a transition temperature within a few degrees of absolute zero. The condition of zero electrical resistivity is also determined by the magnetic field as well as the temperature to which the conductor is subjected. If the conductor is held below the transition temperature, its resistance becomes zero; it remains zero in the presence of a small magnetic field until the field intensity reaches a critical value. Above this value, the material returns to its normal resistance.

Both in principle and in practice, therefore, the conducting properties of a substance – such as a wire, for example – may be made to vanish by maintaining it in an environment within a few degrees of absolute zero, whereas a change from normal conductivity to superconductivity may be effected by

(*Continued on page 256*)

Bradford Washburn

Campus on the Charles – a university polarized about science

The Education of Our Talented Children

Specifically planned to emphasize quality of education, a new type of industrially supported secondary school is proposed, in this condensation of a recent address

by H. G. RICKOVER

Only in the last few years have we begun to see that our trained man-power shortage is the inevitable consequence of a long-term trend in American education which must be halted if we wish to retain our technological lead. To put it bluntly, our schools do not perform their primary purpose which is to train the nation's brain power to the highest potential.

One half of our children who are endowed with the ability to enter college and university do not do so. For every high school graduate who eventually earns a doctoral degree there are 25 others who have the mental capacity to achieve that degree, but do not. If our schools had succeeded in inspiring a love of learning in these children they would have become professional men and women and we would not be faced today with a deficiency of trained man power. Lack of funds is only partly responsible for this irreplaceable loss. Had there been proper motivation, nearly all of these young people could have found ways and means to obtain a professional education.

This is a serious indictment of our schools, but it would be most unfair to place the blame on our harassed teachers and school officials. Inadequate staffs of underpaid and overworked teachers must cope with a tidal wave of children which threatens to overwhelm our crowded schools. No, the blame rests squarely upon us all.

As of today, the American people seem to feel that education is worth no more to them than about half what they are paying for recreation, that is about 4 per cent of the national income.

In recent years, distressing intelligence has reached us that Russia has created a formidable educational system which bids fair to outproduce us in trained personnel. They may even beat us to the goal of becoming the first nation to give every child the opportunity of advancing upward on the educational ladder to the very topmost rung – provided he has the intelligence and applies himself – with tuition, books, room and board entirely provided by the state.

It would be unwise to dismiss as empty boasting Krushchev's remark that Russia will soon have more scientists and engineers than we. She is already training more than her economy presently needs while we are training fewer. Unless we take drastic steps to reverse this trend she will catch up with us and eventually surpass us. The Russian aim is to achieve world scientific and engineering supremacy.

Russia will soon have a *surplus* of trained man power which she can export. We have a *shortage*. Can we allow Russia to outdo us in aiding the neutrals; become Big Brother to backward countries?

No matter what methods are chosen in the duel between the communist and the free world, education will, in the final analysis, determine the outcome, particularly the education of talented youth.

It is therefore most unfortunate that our social mores are hostile to the concept that children of superior mentality ought to receive special consideration at tax-supported schools. The very thought of recognizing differences in intellectual ability is repugnant to our equalitarian philosophy.

In our democratic society we are committed to the basic assumption that there is no person who can claim to be an *indispensable man*. We proceed from this entirely correct assumption to the incorrect conclusion that neither does a democracy have *indispensable men*. This is obviously erroneous. A moment's reflection will show that no society can function without its indispensable men. By this I mean the men who, because of natural endowment and careful training, possess the intellectual, artistic, and moral abilities to carry forward the momentum of civilization and to build upon its existing foundations.

Knowledge Leads to Specialization

It has been estimated that the efforts of a mere 1 per cent of the total population move the world forward. This small group is indispensable to the maintenance and advancement of our civilization.

The more complex a society becomes, the larger proportionately is the number of intelligent, highly trained men needed for its proper functioning. They are the men who provide leadership in government, industry, and labor; the men who think creatively, who invent, who push the boundaries of knowledge outward; the men who enrich life through their moral leadership or artistic gifts – all of the competent people who manage our complex technological civilization. They are all indispensable to our society. We must keep their ranks replenished by the inflow of properly trained youth of superior mental ability if we are to progress in the future as in the past.

It is estimated, for example, that a 3 per cent annual increase in our gross national product will require a 4½ to 5½ per cent annual increase in scientific and engineering man power. Or, to put it differently, in the last 20 years our population has increased by 35 per cent, but the number of scientists has increased by 450 per cent, and engineers by 225 per cent. Yet even this tremendous increase leaves us seriously short. Fifty years ago we needed one engineer for every 1,000 workers; today the proportion is one engineer for 65 workers, and in some industries it is already one for every 20 workers.

Every advance in any given field of knowledge leads to greater specialization; each specialized field in turn requires a new army of people trained for *it* specifically. Today, technological progress is limited only by availability of trained professionals, and this, in turn, depends on but two factors: incidence of superior brain power, over which we have little, if any, control; and development of available talent – here we can do much.

However, for a rough approximation of the percentage of children with sufficient mental capacity to absorb training for a professional career let us take the figure of 15–20 per cent, which includes those having an I.Q. of 115 and over. This incidentally is also the percentage of children who in Europe are able to pass the examinations for entrance to academic secondary schools. I shall henceforth use the term "talented" for the top 15–20 per cent of our children and the word "brilliant" for the top 1½ to 2 per cent.

Very little is done in our schools to seek out and identify this top 15–20 per cent of our children. With few exceptions they are being taught along with the 80 per cent of average and below-average mentality. Up to age 12, the curriculum for all children is the same. In junior and senior high schools a basic core of the curriculum remains obligatory for all, and this is taught in classes which are attended by the whole range from below average to brilliant children. This is so except in some few large high schools where attempts have been made to set up different sections for children having different degrees of ability and achievement. The length of schooling is the same for all children, with some very few instances where talented children are allowed to skip a grade or two.

Now, there is ample evidence that in any class which includes slow and fast learners, the slowest group sets the pace and receives most attention from the teachers. The above-average child is kept from advancing at the speed appropriate to his ability, with the result that many lose interest in learning as such, others develop sloppy habits, and some build up a false sense of superiority which convinces them that they are so smart that they will never need to apply themselves to anything. The deadly routine sets in on these young and malleable minds.

As is often the case, where there is community pressure not to fail the poor student, advancement into the next higher grade becomes virtually automatic. This tends to convince the slow learners and lazy pupils that they can get by without working. Talented children may well resent having to work harder for no tangible reward. All children need incentives to keep up the learning process. Therefore, the practice which is to be found in many schools of "never giving A's," or of "grading the child only as against his own past performance," or of limiting report card comments to "satisfactory" and "needs improvement," is a particularly unfortunate concession to a dubious tenderness for the sensibilities of those parents whose children show neither ability nor a desire to learn.

Superior Student Inadequately Served

In addition to the common core of obligatory courses, our high schools offer a wide choice of elective subjects from which each child may pick those he prefers. Among the electives there are the tough academic subjects which constitute the college preparatory program – mathematics, algebra, geometry, trigonometry, physics, chemistry, biology, foreign languages; there are the vocational subjects which make much less demand on the intellect or will power since little homework is required – domestic sciences for the girls, and various trade skills for the boys; finally there are the subjects of a recreational nature – square dancing comes to mind – or those which in a vague sort of way aim to train children in co-operative and mutually helpful living – courses in social manners, life adjustment, the art of makeup, and how to attract the opposite sex.

All except the academic subjects are of the kind which we might term "know-how." That is, they have nothing to do with the school's primary task which is

to teach young minds to think and to train them in the elementary tools of learning. This is a task which can be performed only by the school. Vocational, recreational, or life-adjustment training can be and should be obtained elsewhere. Our teacher shortage would be greatly lessened if we relieved them of all responsibilities except those of teaching the *minds* of children and developing their *bodies* through physical training.

This may sound strange to us, accustomed as we are to the intermingling in our schools of academic and vocational training, and to the great emphasis given to social activities. But we are the only country where schools are part social institutions; everywhere else children receive academic training in general schools, and vocational training in special vocational schools or through on-the-job training programs combined with general education at special secondary schools.

The Exceptional Child

In nearly all respects the mentally superior child is less adequately served at school – taking into account its special requirements – than the average or, for that matter, the physically or mentally handicapped child. I realize, of course, that we must and should make special provision for unfortunate children. Our hearts are here involved and it is to the credit of our people that they will readily abandon such cherished principles as "equal education for all" to answer the call of compassion. Yet why should we show less compassion for the mentally superior child whose fine abilities are being left untended? Oddly revealing of American thinking is the fact that the term "exceptional child" conjures up to most educators not the talented child but the handicapped one. Books and magazines dealing with exceptional children seldom give more than perhaps 1 per cent or so of space to the needs of the talented child.

Nor are we sufficiently aware that, in the final analysis, our cherished American standard of living is largely dependent on the work of a very small group of skilled professionals. In part, this is a consequence of a curious inconsistency in our attitude toward "science" as against "scientists" and "scholars." We admire science greatly and we place in it an almost childlike trust; we expect it will continuously pour out delightful wonders to make our lives ever more agreeable. But upon scientists and scholars many of us look with a somewhat jaundiced eye; we call them "eggheads" and "intellectuals"; we do not consider them to be entirely normal persons. In truth, we have no real admiration for higher learning as such, nor are we willing to respect those engaged in it unless we see an immediate practical advantage to ourselves in their work. Most Americans dislike the very idea that people are unequal in intellectual capability, though they are ready enough to recognize inequality of natural endowment in other respects. This ambivalence in our attitude toward the mentally superior is surprising when we compare it with the generous applause we lavish on superior talent in athletics or in the arts; on superior beauty or on superior business acumen.

Although not all talented children are academically inclined, enough of them do so well at institutions of higher learning that the spending of public funds for the better education of all talented youth is an exceedingly good investment for the nation as a whole, and would do much to relieve our national deficit in trained professionals.

It is well to remember that the transformation of the traditionally academic American high school into a combination college preparatory, vocational, and social institution came about in response to the demand for schooling of a type more appropriate to the majority of children – those who could not or did not want to take academic courses but whose parents nevertheless wished them to attend high school. As nonacademic, know-how subjects wormed themselves into the curriculum, the high school became less and less able to give proper attention to the special educational needs of the minority of children whose superior intellect could find no challenge in downgraded curricula. This is particularly true in small communities where the college preparatory program of the high school is apt to be curtailed whenever shortages of school funds or teachers occur.

Almost half our high schools teach no foreign languages – and this at a time when our foreign commitments call for a large corps of trained men and women with linguistic as well as professional ability. Almost a quarter of the high schools offer no physics, chemistry or geometry – and this at a time when a grounding in science becomes more and more important for everyone, including those not in academic careers.

As a matter of fact, I seriously question whether substitution of "know-how" subjects for academic subjects benefits even those children who do not intend to follow academic careers. A great deal of this high school training in "know-how" is wasted because obsolete methods, equipment, and instruction are used. Such training is primarily the job of industry and can be done much better and in considerably less time in a factory than in a high school. Education is not a process for transmitting techniques.

Eliminate "Know-How" Subjects

Today every citizen needs the tools of thinking – the three R's – reading, writing, and arithmetic – and such general knowledge of history, civics, and literature as will make the world we live in understandable. In our technical civilization, manual and white collar workers, tradesmen and merchants – in short, everyone needs as much general education as he can possibly be coaxed to absorb. It isn't doing our children any favor to spare them all mental effort by making school too easy and too pleasant, and to substitute "know-how" subjects of doubtful value for mental training.

Eliminating "know-how" subjects from the high school curriculum and requiring all students to take more academic ones does not solve the problem of our talented children. It is high time that we recognize their right, even if they are a minority, to schooling appropriate to their needs. For the last 50 years we have, in the name of educational democracy,

tried to make one common school serve all children instead of finding the appropriate school for the two main groups of children – the majority who plan on nonacademic careers, and the minority who plan for college and university. We must reverse this unfortunate trend in American education.

Let me remind you of the separate purposes and traditions of academic and nonacademic schooling.

It was Socrates who said that "knowledge is virtue." Though there have been regrettable lapses, Western civilization has never completely lost sight of this truism. The Greeks, alone of all the nations of the ancient world, placed knowledge and the power of thought above all other pursuits as being most worthy of a civilized man and a civilized state. We are indebted to them for that marvelous pedagogical invention – the liberal arts curriculum – which has never been surpassed for training the young to think, to use their brains in solving particular problems, and for providing a broad basis of general knowledge upon which specialized training could later safely be superimposed. We are rediscovering that a professional man needs the foundation of a liberal arts education in order to use his specialized training wisely. The man who is highly trained in only one field of knowledge and illiterate in all others can be a positive danger to society.

Rome went to school in Greece, and so Greek ideas on education spread throughout Europe. When Rome fell, Europe was more literate, it had more books, libraries, and schools than at any time during the next thousand years. Only a dim flicker of learning was kept alive by the Church. From this and from the knowledge of the ancient world which had been preserved in Arab schools and was transmitted westward during the Crusades, Europe rebuilt its education. In the Twelfth Century universities made their appearance and soon spread all over Europe – there were 108 by the year 1600. Latin was the language of the Church, and since churchmen made up the faculties of medieval universities, Latin was the language which every person had to learn to enter a university to study for a professional career.

To this end, so-called Latin schools were founded in which youngsters were given a classical education preparatory to enrollment in the university. Sometimes these schools were attached to a cathedral, sometimes they were set up by private endowment, or founded by kings as charitable institutions for children of poor or deceased courtiers. These Latin schools, or grammar schools, as they are still called in England, are the forerunners of European – and of early American – secondary schools. Although the brilliant child of poor parents was seldom barred from these schools and scholarships were always available, the secondary schools were used for the most part by children from well-to-do homes.

Alongside this education for children destined for political leadership or for professional careers, there developed an entirely separate system of education for the common people. In the late Middle Ages, cities rose to power and wealth. Their craftsmen and merchants found that elementary knowledge – the three "R's" – was of practical use to them. They therefore founded schools where their children could be taught these subjects. Since these children were not intended for the universities, Latin was not needed, and the schools therefore taught in the vernacular. These schools later became the elementary schools and were eventually taken over by the state. This elementary education originally lasted for three years but was gradually extended to eight years as technological progress raised the standards of general knowledge and the primary skills required, even of

Lockheed News Bureau

In the last 20 years our population has increased by 35 per cent, but the number of scientists has increased by 450 per cent and engineers by 225 per cent. Yet even this tremendous increase leaves us short. Fifty years ago we needed one engineer for every 1,000 workers; today the proportion is one engineer for 65 workers, and in some industries it is already one for every 20 workers.

In the final analysis, our cherished American standard of living is largely dependent on the work of a very small group of skilled professionals. In part, this is a consequence of a curious inconsistency in our attitude toward "science" as against "scientists" and "scholars."

persons in nonacademic careers. For these and humanitarian reasons, child labor was ultimately outlawed and the compulsory school age progressively extended. In the United States, as in most of Europe, this is now age 16.

As a result of the rise of labor to political power and a general movement toward greater democracy, European schools have lost much of their class character. In England public secondary schools of all types are now free of charge, and some three fourths of the undergraduates, even at Oxford and Cambridge, receive financial assistance from the government. In continental Europe, elementary education has been both free and compulsory for more than 150 years. Secondary education has been a state enterprise for almost as long, and school fees have always been moderate; in addition, scholarships have been available for the gifted poor. Secondary school fees have now largely been abolished or scaled to fit the financial resources of the parents. Even universities have become free in some countries and are inexpensive everywhere on the continent.

Separation of Talented and Untalented

But while the educational ladder has been opened throughout Europe, the separation of the two educational tracks has been retained. At 10 or 11, if they can pass the entrance examinations for academic secondary schools, children may enter the upper track – about 15 per cent achieve this. The remainder enter one of several other types of secondary schools, depending on whether they seek a general education not as demanding as that of the academic secondary schools, or whether they seek immediate training for their future careers. In this latter case they enter a commercial or trade school which gives some general education but with emphasis on vocational training.

Most of the liberal arts education given in our liberal arts colleges has been absorbed into the curriculum of the European academic secondary schools; the remainder has been incorporated into the faculties of philosophy of the universities. England has a three-year college course but it is far more centered on the student's special professional interest than is customary in our colleges.

In general, the European student is ready to begin his specialized professional studies from two to three years before his American counterpart. This is due to the early separation, in Europe, of talented children into schools which they attend for a period of eight or nine years. This long stay in a single school allows for a carefully planned curriculum in which subject follows subject in logical sequence. No choice is left to the pupil except at the outset when he may choose among three types of academic secondary schools: classical; modern, with emphasis on the sciences; and the third type which combines parts of both.

European children go to school six days a week; their school day is longer, and school vacations are shorter than here. Frequent examinations weed out the incompetent or the lazy. This rigorous intellectual discipline results in a reduction of two to three years in the time needed to educate the professional man.

A hundred years ago, Americans could be proud that we were the first country in the world to promote free secondary school education for all children. However, today free secondary school education has been achieved or is well on the way to being achieved in all of Europe. But where we have lowered our secondary school curriculum to accommodate all children, Europe has maintained the high standing of its academic secondary schools and has provided special secondary vocational and trade schools for those unable to absorb academic training.

I have seen it boasted that 83 per cent of our children of high school age attend high school and that 55 per cent graduate. These figures lose their force when we realize that many of these graduates have had no more of an education than European youngsters who attend the lower-track secondary schools.

Our high schools may excel in turning out pleasant and attractive youngsters, but their heterogeneous character makes them poor institutions for training the talented.

When the great inflow into our high schools began after World War I, some 80 per cent of the students were found incapable of absorbing the academic subjects being taught. Community pressure and political expediency forced the schools to downgrade the curriculum. Now that the great inflow into the colleges is about to begin, something similar may well happen there. Already we have a number of colleges which are hardly better than secondary schools. Already we have state universities which are required by law to admit all high school graduates from the home state, or all those with a C average – obviously not college material. This shows up in their fantastic first-year failures: in some instances 40 per cent fail at the end of freshman year. One might compare this with the 2 per cent first-year failures at Ivy League colleges where students have been carefully screened for scholastic aptitude. Requiring state colleges to admit students unable to do college work is a waste of tax money which could be used to better advantage on higher salaries to obtain better teachers.

Injustice to Talent

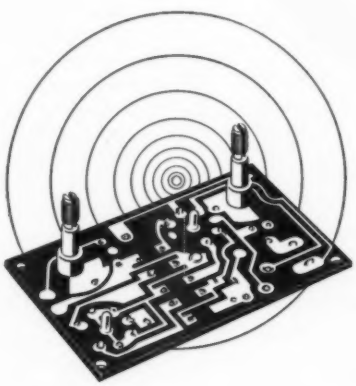
But even worse than wasting expensive schooling on children who are neither able nor want to absorb it, is the damage done to our talented youth who are forced to waste two or three important years of their lives in omnibus schools unless their parents are rich enough to send them to private college preparatory schools. We shall not do justice to our talented youth until we seek them out at an early age – no later than 10 or 11 – and educate them separately from the rest of the children. This need not necessarily be in a separate school; it could be in a college preparatory section of the school. But this separate schooling must begin earlier than junior high school. It should start after the fourth grade or, at the latest, the fifth grade. The schooling must be purely academic, and the teachers must have professional competence in the subjects they teach. Admission as well as advancement into each higher grade should be by examination. If possible, the school year should be extended

(*Continued on page 266*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

"Printed circuits!" "Printed circuits!" You hear it on all sides today. And well you might. For printed circuits have so many advantages. They have compactness as compared to conventional wiring and compactness that makes possible better assembly arrangements and techniques. Numerous, time-consuming hand operations are eliminated, there are fewer rejects, shorter, less intricate assembly lines, and fewer soldering operations, as with printed circuits a single dip-soldering operation can solder all joints at once.



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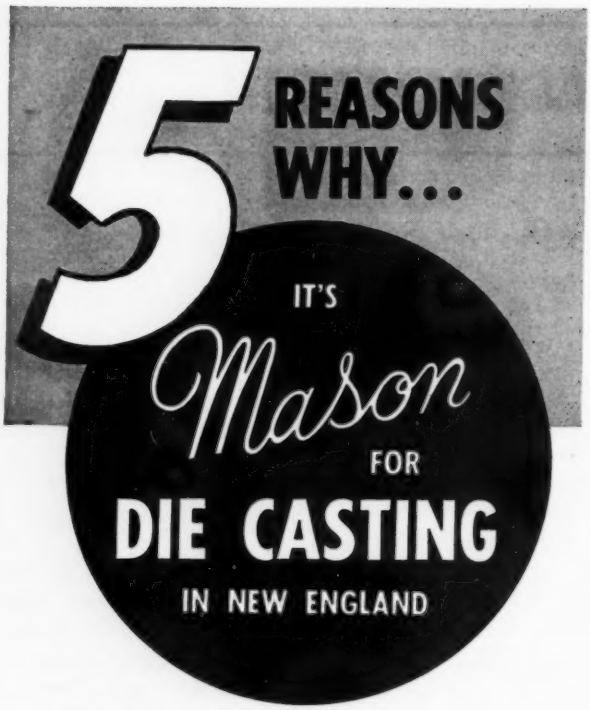

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TREND OF AFFAIRS

(*Concluded from page 244*)

sional workers, whereas the corresponding figure in the United States is something like 1,000. Mr. Korol felt, however, that the most significant element of Soviet education was its absolute authority to allocate trained personnel in whatever areas it chose, leaving the individual no choice to pursue his own desires.

Dr. Hagen, formerly economic adviser to the Burmese government, discussed some of the problems involved in the transfer of technology to underdeveloped countries and the ways in which the manner of transfer affects the international position of the United States. Although it is natural to think that greatest progress can be made when the most advanced productive techniques are transferred to less developed regions, lack of needed communication, transportation, and subsidiary services places severe limits on this approach. So, too, do the economic, political, and religious views of the citizens, which cannot be lightly dismissed. Even so simple a technological advance as introduction of a shovel for a wooden hoe, in one part of the Orient, was found to be impractical because the natives had no shoes, and to supply them with footwear raised severe social and economic problems. Dr. Hagen's view was that as much harm as good may be done in attempting to aid underdeveloped countries unless thorough attention is given to the economic, social, religious, and political problems as well as the purely technical ones.

Chancellor Stratton reported that the Institute will dedicate this June the $4,200,000 laboratory for education and research in nuclear science and electronics.

The meeting was concluded with the showing of "The Social Beaver," a new motion picture on student life at M.I.T., filmed and produced by Oscar H. Horovitz, '22, and described on page 147 of the January, 1957, issue of The Review.

THE CRYOTRON

(*Continued from page 249*)

control of suitably applied magnetic field. The magnetic field may be produced by winding a coil around the conductor and passing current through the coil. By varying the current through the coil to control the magnetic field it produces, the resistance of the low-temperature conductor can be substantially changed rather abruptly. In effect, such a structure constitutes an electromagnet, with the straight conductor serving as the core. Current through the winding of the electromagnet is then used to switch the conducting properties of the core (which, in the case of the cryotron, is simply a straight wire of tantalum) from zero to finite value. The coil of the electromagnet, like its core, is operated at very low temperatures and is superconducting. Hence, a current once started in its winding, requires no power for its maintenance.

(***Concluded on page 258***)

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Some of the techniques used have made possible an increased range for given levels of transmitter power and reliability of communications. Others have provided specific advantages in very long distance communications or in operational situations requiring unique signaling capabilities. Developments in navigation systems have resulted in new equipment that is suitable for the guidance of aircraft at long ranges from their bases.

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- Airborne transmitters
- Transistorized video and pulse circuitry
- Airborne receivers
- Reconnaisance systems
- Digital communications systems

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THE CRYOTRON

(*Concluded from page 256*)

The first comprehensive report on cryotron research appeared as an article, "The Cryotron – A Superconductive Computer Component," by Mr. Buck, and appeared in the April, 1956, issue of the *Proceedings of the Institute of Radio Engineers*. Mr. Buck's paper outlined the operating principle of the cryotron and illustrated the application of cryotrons to the design of modern, large-scale computing machines. For his paper on the cryotron, Mr. Buck will receive the Browder J. Thompson Memorial Prize of the Institute of Radio Engineers. This prize is awarded annually to the author, not more than 30 years of age, "for that paper of sound merit recently published in one of the technical publications of the I.R.E. which has been selected as constituting the best combination of technical contribution to radio and electronics and presentation of the subject."

The first data-processing equipment in which the simple, tiny device will replace electron tubes or transistors is now being built at Arthur D. Little, Inc. The first cryotron electronic catalogue will use 215,000 cryotrons. A conventional computer designed to do the same job might require 50,000 vacuum tubes. It is estimated that the cryotron elements for a large-scale computer can be made to occupy not more than one cubic foot of space. In addition, space would also be needed for the terminal equipment and for the low-temperature cryostat. Even so, considerable saving of space is envisioned.

EDUCATION FOR UNDERSTANDING

(*Continued from page 248*)

I believe it can be said that no single thing would do so much to reduce the shortage of scientists and engineers, to increase the understanding of the American people of the technological society in which they live, and thus to increase the probability of an intelligent solution to national problems, than to double the quantity and improve the quality of the mathematics taken by the average high school graduate.

Curiously enough, I believe that this suggestion is quite noncontroversial. Everyone believes in more mathematics. It is just a question of doing something about it. I would even go so far as to propose that every major high school (rather than only a few) offer work in calculus for the well-prepared high school seniors. This would help enormously in preparing scientists and engineers and would be an incentive for better preparation of high school teachers as well.

But if we agree on more mathematics for more students, what about more science? Here we confront a very serious current illusion which has become widespread in America. The illusion goes like this: Science has created some terrible weapons of war; therefore it is better to abandon the study of science and "return to the liberal arts."

Of course, the argument is never stated quite as baldly as that. There are always long disquisitions

(*Continued on page 260*)

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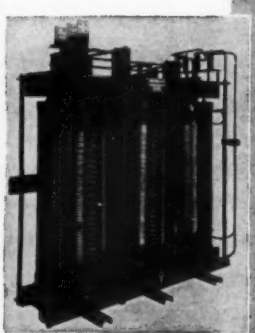

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EDUCATION FOR UNDERSTANDING

(*Continued from page 258*)

about how people must learn to live together – which is certainly true. But then they come up with the astonishing and wholly unwarranted conclusion: To get along with people we need less emphasis on science and more on something else. Just how it will make the Russian leaders behave any better to tell American boys not to study science has somehow always escaped me!

The giveaway is, of course, that no two people agree on what the "something else" should be that replaces science. Some say history, some say American Constitution, others say religion, others argue for the great books; others just pass a law requiring a course in automobile driving.

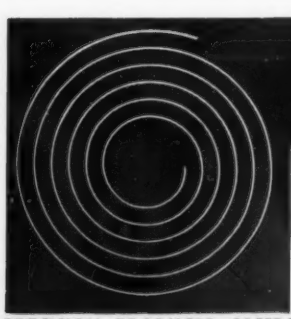
But this is an age of science and technology! Our military strength, our economic progress, the welfare of future generations, will be largely determined by our success in developing new weapons, new materials, new sources of food for hungry millions, new materials to replace our dwindling mineral resources, larger and cheaper sources of energy to do our work, new knowledge to improve human health, and new ways to take advantage of a growing technology, as well as new ways of operating, controlling, and governing the technological society we are creating.

Solving the Problem

Are these problems going to be solved by young men who have been advised against taking science because it is too hard? Are they going to be solved if the future generation cannot even understand the language in which these technical problems must be described? Even today there are great public arguments about fallout from H-bombs, freshening of sea water, guided missiles and earth satellites, fluoridation of drinking water — arguments often carried on without a trace of understanding of the technical facts involved. Can such arguments be counted on to produce sound decisions?

An advancing civilization requires an ever-larger fraction of its population to be engaged directly in scientific and technological pursuits; it requires also that a larger fraction shall be aware of the technical foundation on which modern living is based, so that intelligent decisions may be made which affect future welfare or future security.

(*Continued on page 262*)



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EDUCATION FOR UNDERSTANDING

(*Continued from page 260*)

But, even more, a great obligation of our schools is to recognize that while in 1856 the frontiers of America were the frontiers of the West, so in 1956 the new frontiers are the frontiers of the mind. America will expand no more by geographical growth. But the frontiers of the mind are without limit.

Shall our young people be forever closed off from understanding these frontiers? Adventures more exciting than those of Columbus or Magellan or Buffalo Bill or Davy Crockett are taking place now, today, on these frontiers of science. Science is not just a way of earning a living, it is understanding how the universe is built and how it behaves.

We hear a lot about hydrogen bombs, and how terrible it was that men invented them. Well, man did not invent them – or at least the Creator beat him to it. For our own sun is nothing but a continuously operating H-bomb. The energy of the sun is produced by the conversion of hydrogen into helium – and that has been going on for five billion years. There is enough hydrogen left to keep things burning for another five billion years. The Milky Way contains many billion stars like our sun and there are many millions of other galaxies like the Milky Way, each containing a few billion suns. The sun, in fact, is rather a smallish star compared to most of the others. And these galaxies stretch out into space so far that it takes the light from them two billion years – traveling at 186,000 miles per second – to reach the earth.

I have a friend to whom I gave a photograph – taken with the 200-inch telescope – of the great galaxy of stars known as the great Andromeda nebula. It is some two million light years beyond the boundaries of our galaxy, the Milky Way. He tells me that whenever he is depressed by difficult problems he looks at the great nebula, and his problems seem to sink to insignificance. That picture has done more to make him live happily and get along with people than a dozen college courses in social science or human relations. That is the important thing about science that people forget. The advancement of man's knowledge and understanding is essential to lifting his spirit.

Who is it that explores and pushes back these frontiers of the mind? Who leads the adventures into new areas of intellectual achievement? As I have said before, it is the educated leaders of the world. At the very vanguard, of course, are those great intellectual giants who make the great "breakthroughs" in the battle against the unknown – the Galileos and Newtons and Maxwells and Rutherfords and Bohrs and Einsteins.

Then come the larger number of men and women who back up these leaders – the officer corps, if you will – the colonels and majors and lieutenants – who

(*Concluded on page 264*)

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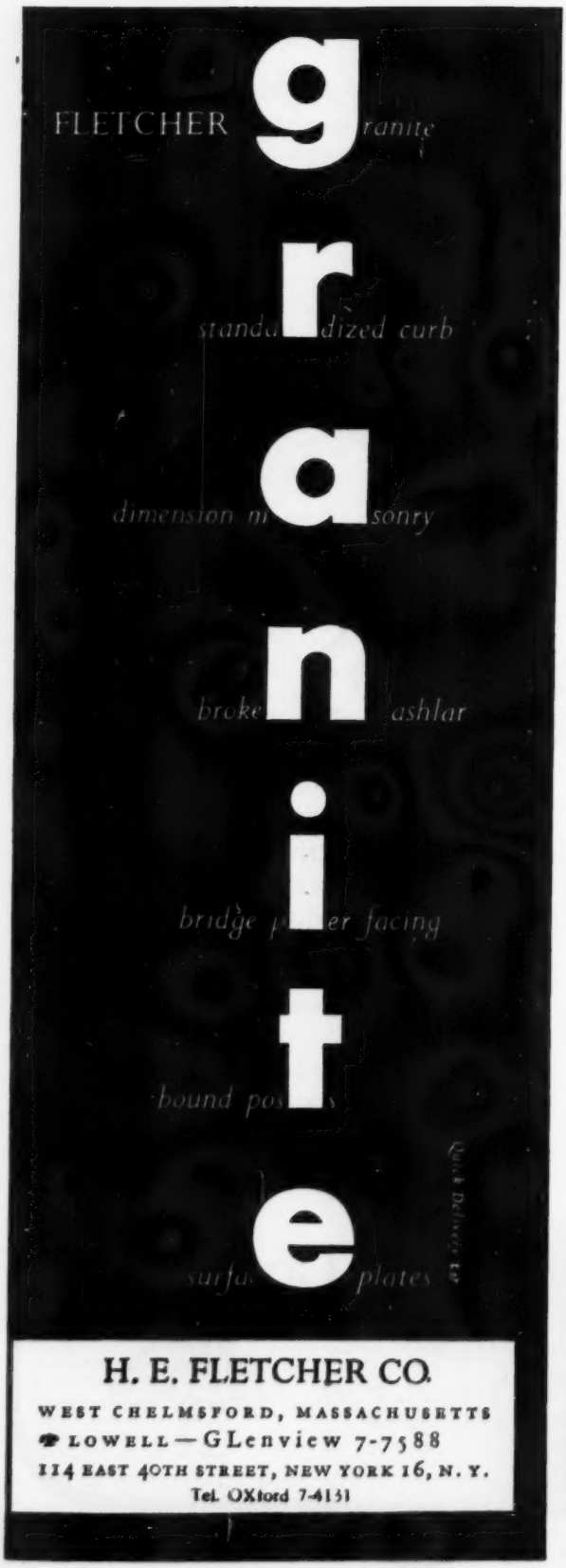

EDUCATION FOR UNDERSTANDING

(*Concluded from page 262*)

follow up and consolidate the breakthroughs. These are the scientists and engineers of the country — an elite group still consisting of possibly only 1 or 2 per cent of the nation's workers. Then come the followers — particularly the great body of men and women who have progressed at least through high school and who do the most to set the tone of the nation's intellectual, cultural, moral, political, social, and business activities. How are we doing in educating these various groups?

We are doing moderately well in making educational opportunity available to everyone. Nearly all of our young people (except the handicapped) in many states finish high school. In California, for example, some 50 per cent of the high school graduates will enter college next fall. Fifty per cent! No longer are our high schools swamped with those who are not preparing for higher education; higher education is now the goal, the hope, of the majority! Are these young people going out well prepared for the additional intellectual toughening and development which college aims to give? Are they prepared to meet the new rigors with enthusiasm and determination? More important, have any boys and girls of first-rate mental caliber been discouraged in school — discouraged by neglect, because their full talents were never challenged, were never given an opportunity to develop?

Encourage the Leaders

How are we doing, in other words, in encouraging the leaders? The Einsteins can take care of themselves. But the thousands of young men and women who constitute the top 5 or 10 per cent of the population in intellectual ability — are we finding and encouraging them to find their talents and interests and develop them to the utmost? I can think of no more important task in the world. The course of future American history will depend far more on how well our homes and schools and colleges perform that task than it will depend on what happens to the stock market or on who won the election. For our schools and colleges have custody of the community's brain power, of the intellectual resources of the future. It is those resources which *determine* the future.

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Seven years ago, a Stanford graduate joined New England Life at our branch office in Palo Alto, California. Six months later, another Stanford man arrived. Then, within three years, two other Stanford stalwarts were saying, "Move over, fellows."

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SOX4-20	20	4	.310
SOX7-20	20	7	.365
SOX9-20	20	9	.415
SOX2-18	18	2	.350
SOX3-18	18	3	.365
SOX4-18	18	4	.395
SOX7-18	18	7	.390
SOX9-18	18	7	.390
SOX2-16	16	2	.380
SOX2-14	14	2	.450

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EDUCATION OF TALENTED CHILDREN

(*Continued from page 254*)

to 210 days. There is no other country of comparable civilization where children go to school for only 180 days as they do here. This may have made sense when we were an agricultural country and children were needed to help on the farm. But our long vacations make no sense today, especially when we consider how rapidly knowledge is increasing and how much more a child must now learn to become truly educated. The more we know, the more there is to know.

The undue length of professional education in America is a significant element in our trained manpower deficit. Today, the American professional man will complete his education when he is between 25 and 26, and for most there will have to be added two additional years of military service before they can become self-supporting. All of this becomes particularly onerous in the United States where early marriage is part of our social pattern. Surely, we must do all we can to allow our talented youth to move through their schooling at their own rate of progress and not retard them by the pace of the average or the slow learner.

I am aware that any change in the American public school system will meet opposition. Special schooling for the mentally superior will be branded as "undemocratic" and as "class" education. It will be considered unfair to give the talented child education superior to that offered the average. It will be said that the separation of children according to mental capacity will deny them valuable experience in living together with other children of varied background and ability, and that this constitutes an important ingredient in the smooth functioning of American democracy – so it will be said. None of these objections, however, bears critical examination.

It would, indeed, be undemocratic to propose a cleavage along class lines, but not one along the lines of natural ability, which hardly anyone will claim is limited to the children coming from better homes. It is, however, often forgotten that we already have just such a separation along class lines in large American cities where schools draw their pupils from a particular neighborhood rather than from the whole population, as is the case in smaller towns. Neighborhoods in America are usually homogeneous, at least as far

(*Continued on page 268*)

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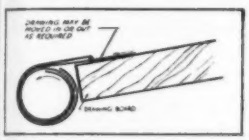

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EDUCATION OF TALENTED CHILDREN

(*Continued from page 266*)

as the finances of families are concerned. Parents in better class neighborhoods generally succeed in obtaining better schools for their children. Finally, we must not forget that well-to-do parents always have it in their power to assure their children a good education by sending them to private preparatory schools. But the talented poor child must depend solely on the public school. Education in a democracy must not only be democratic, it must also be education.

Education is not a commodity such as a house, a television set, or an automobile. Everyone can use and enjoy a house, a TV set, or a car; it would indeed be unfair if the state distributed these commodities free of charge but limited them to only part of the population. The ability to use and enjoy academic training, on the other hand, is not universal; therefore, to limit it to those who can benefit from it is not unfair; but, to deny it to the minority who can use and derive benefit from academic training is both unfair and undemocratic, as well as a waste of our most valuable national asset.

Is money the problem? Then what are we going to do with all our wealth? If an additional four billion dollars a year – 1 per cent of our gross national product – makes the difference between good teachers and mediocre ones, good schools and poor ones, can we afford not to spend that sum? Is our end aim merely to become more wealthy, to acquire more things?

A Proposal

Can we afford to make our talented children remain in school any longer than they have to, when our schools are already so overcrowded and the teachers so few?

I suggest that industry, together with our educational foundations undertake the setting up of model academic secondary schools in perhaps 25 different centers in the United States. These schools would be on a par with our best academic secondary schools. They would be free; the ability to pass an entrance examination of a kind which would weed out those not mentally capable of absorbing an academic secondary education would be the only requirement.

(*Concluded on page 270*)

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EDUCATION OF TALENTED CHILDREN

(*Concluded from page 268*)

The schools would be staffed by teachers truly capable of teaching talented children; teachers whose qualifications place less emphasis on training in teaching *methods* and more on graduate study in their fields. The competence of European secondary school teachers, based as it is on years of postgraduate study in their fields, is one of the main reasons why they can teach as much in 12 years as ours do in 14 or 15.

Teachers' salaries in these schools would be in accord with the high scholastic qualifications required and, therefore, equal to those paid for comparable positions in industry. Such salaries would attract competent teachers.

These model schools should aim at a ratio of at least one teacher for every 20 pupils. One of the reasons why the private English boarding schools, such as Eton, Harrow, and so on, contribute so large a percentage of England's leaders is their ratio of teachers to pupils — one for every 12 students.

The schools would start with the fifth grade so as to have the pupils ready for college at 16. To do this it may be necessary to provide a choice: students could complete the course the regular way in seven years, or they could finish in six years by taking extra courses during three summers. We must find a way for our children to attend school for more than the present 180 days. Lengthening the time in school might most easily be done through the medium of voluntary summer courses.

Teachers in these schools would be given no extra-curricular work of any kind, because a teacher, as does any professional person, requires time for thought and study. The schools would be scholastic institutions, so social activities would be kept at a minimum.

The management of these schools, qualifications and salaries of teachers, entrance requirements, curricula, and standards would be left to an independent body not connected directly with the donor. But I see no reason why the schools could not be given names to indicate the corporation, or industry or labor organization — for labor ought to participate in this endeavor no less than industry — which contributes financial support. This seems to me fair and legitimate, and even desirable; it would win friends for industry as a whole, and for the donor in particular.

I estimate that the cost of operating each model school for a period of five years will be about $10,000,000. At the end of that period the community ought to have an option to take over the school, provided it agrees to continue the high scholastic standards set under private management.

These model schools would demonstrate what could be accomplished by competent teachers, a proper curriculum, and an adequate school year. They would be goals and living examples of what can be done by the community for the education of its children.

These are my suggestions. Others can and will be made. But let us make a start.

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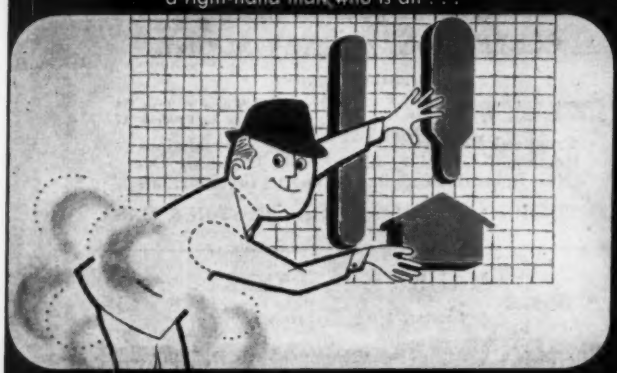

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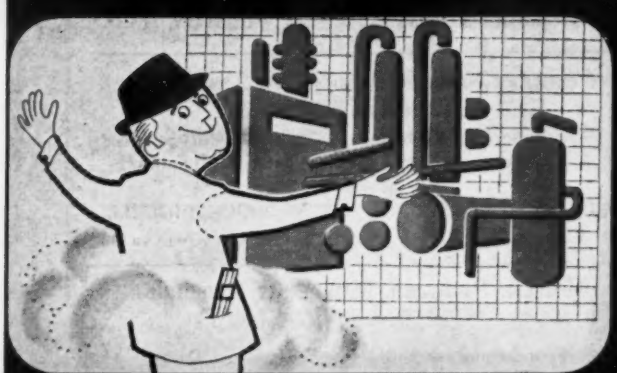

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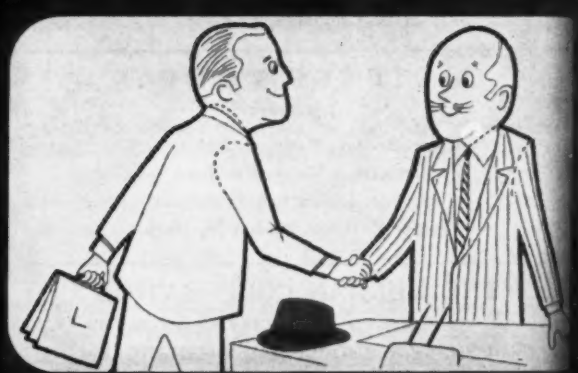

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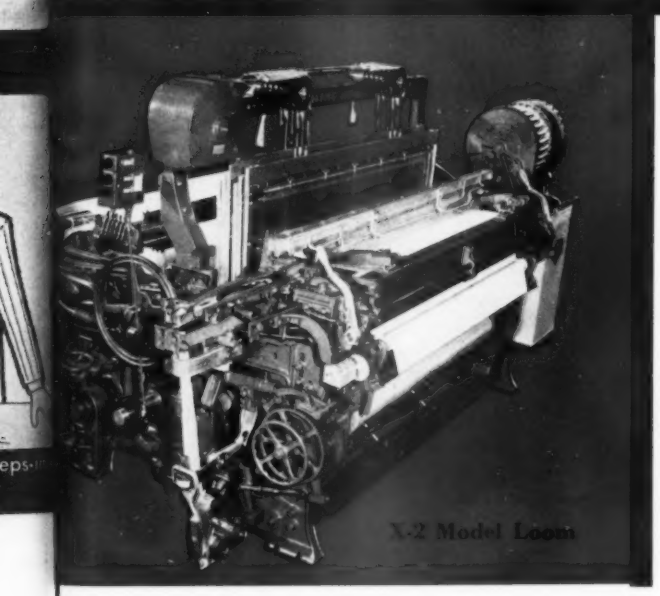

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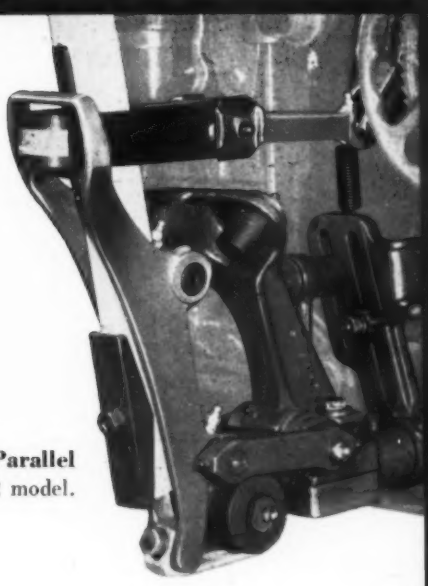

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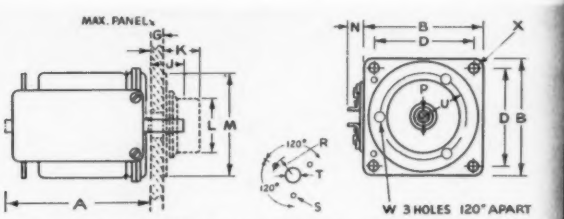
At very slight increase in price you get an increase of 365 va in capacity with the same exclusive advantages found in all VARIACS: Duratrak brush track construction — excellent regulation — perfectly smooth control — low losses — linear output voltage — moderate temperature rise — the most advanced mechanical design for long, efficient, trouble-free, low-maintenance life.

The physical size and all mounting dimensions of the new Type W5L are identical with those of Type W5.

type **W5L**
Variac:
$17.50
1265 va rating, 8.5 amps. rated, 11.0 amps. maximum



Essential Dimensions Type **W5L** *VARIAC*

	A	B	D	G	J	K	L	M	N	P	R	S	T	U	W	X
W5L	3 5/16"	4 1/2"	3 1/4"	3/8"	1 1/16"	1 3/16"	2 1/8"	4"	7/16"	3/8"	5/8"	#31	1/2"	1 1/4"	10-32	1/4"

Input Voltage	**115 volts, 60 cycles**	No. of Turns on Winding	235
Load Rating (va)	**1265**	D-C Resistance of Winding (Ω)	0.926
Output Voltage	0 to 115	Driving Torque (oz.-in.)	10-20
Rated Current (amp)	8.5	Replacement Brushes	VB-2 75¢
Maximum Current (amp)	11.0	Net Weight (lbs.)	6½
No-Load Loss at 60 c (w)	12	Code Word	COTUG
Dial Calibration	0-115*	**Price**	**$17.50**
Angle of Rotation (deg.)	325	Ball Bearing Surcharge (Add "BB" suffix to type number)	$7.00

*The 0-135 dial calibration on reverse is not used with the Type W5L

GENERAL RADIO Company

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